

FEDERAL LEADERSHIP IN SCIENCE

HEARING
BEFORE THE
COMMITTEE ON
LABOR AND HUMAN RESOURCES
UNITED STATES SENATE
ONE HUNDRED FIRST CONGRESS
FIRST SESSION

ON
EXAMINING THE FEDERAL GOVERNMENT'S ROLE IN SCIENTIFIC
RESEARCH, EDUCATION, AND INNOVATION

APRIL 6, 1989



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FEDERAL LEADERSHIP IN SCIENCE

THURSDAY, APRIL 6, 1989

U.S. SENATE,
COMMITTEE ON LABOR AND HUMAN RESOURCES,
Washington, DC.

The committee met, pursuant to notice, at 9:40 a.m., in room SD-430, Dirksen Senate Office Building, Senator Edward M. Kennedy (chairman of the committee) presiding.

Present: Senators Kennedy, Pell, and Jeffords.

OPENING STATEMENT OF SENATOR KENNEDY

The CHAIRMAN. We will come to order. The subject of today's hearing is America's leadership, or lack of it, in the vitally important areas of scientific research, education and innovation. Few other issues are more significant to the Nation's future prosperity and progress.

The caliber of our science and technology underpins our economic security and our economic competitiveness. They have a central role in health care, the quality of the environment, and many other domestic challenges.

Twenty years ago this July, when our astronauts landed on the moon, America's preeminence in science and technology was unquestioned. Students were inspired to begin careers in science and engineering. America's high-tech industry—in aerospace, semiconductors and computers—became the envy of the world.

Today the engine of America's scientific and technical enterprise is sputtering. Our generation is coasting on the achievements of the past two decades, but the next generation is in jeopardy.

Students of today consistently score lower on math and science tests than their counterparts in other industrial nations. In a recent survey of eighth-graders, American pupils ranked last of 12 countries in math and ninth in science. Sixty thousand secondary school math and science teachers are not qualified to teach their subjects.

At the college level, only 5 percent of freshmen in 1985 planned to major in basic science—half the rate of 1976. In graduate school, more than 50 percent of the engineering doctorate degrees earned in American universities are awarded to foreign students.

If present trends continue, the Nation faces a shortfall of over 500,000 scientists and engineers by the year 2010. Our research infrastructure—university facilities and equipment—is also in poor condition. Over the past 20 years, funding has declined by 95 percent in real dollars. A 1986 White House science study estimated

that a \$10 billion program over the next decade would be needed to restore these facilities to an adequate level.

Overall, we spend a smaller share of our budget on civilian R and D than Japan, West Germany, France, the United Kingdom and Sweden.

The chart indicates the trend lines that we have seen from 1971 up to 1987. Clearly, our major competitors, certainly, Japan and West Germany, have consistently had a higher percentage of GNP in R and D non-defense expenditures; France has been moving up consistently, and even the U.K.

U.S. spending on civilian R and D as a fraction of GNP has stagnated at 1.8 percent.

The real meaning of these numbers is defined by America's declining competitiveness. The current situation is bad enough, but the trend is unacceptable.

I think the other chart is a pretty clear indication of what is happening with the U.S. share of technology markets. If we look at the left and the list of various industries and technology, we can see where the United States pioneered in all of those areas, where we are in 1970, 1980 and 1987; the flow lines are very clear.

To reverse these trends and restore America's preeminence, we need strong Federal leadership in five critical areas: scientific literacy, scientific and technical personnel, facilities and equipment, research and development, and technology transfer.

The Science Adviser to the President must play a key role in providing that leadership. We hope that President Bush will act quickly to appoint a Science Adviser. This is not a partisan issue, but it is an issue that needs to be addressed on an urgent basis, with as much bipartisan cooperation as we can muster between Congress and the Administration.

It is not "morning in America" in science, and I want to see our Nation second to none again in science and technology—not second to Western Europe and Japan.

We have a very distinguished group of witnesses this morning. I appreciate their adjusting their schedules. We have been called by the leadership to attend a bicentennial celebration later in the morning. The beginning of the meeting is at 11:00, and the second part of the meeting is at 11:30, at which time I intend to speak for Massachusetts as they call the roll of Senators according to the time that they were admitted to the Union. So I appreciate the adjustment of our witnesses' schedules here this morning.

Before introducing them, I will recognize a very good friend and the chairman of the Education Subcommittee and someone who has really made a very important contribution and a difference in education in the United States, Claiborne Pell.

Senator Pell?

OPENING STATEMENT OF SENATOR PELL

Senator PELL. Thank you very much, Mr. Chairman.

I commend and congratulate you on convening this hearing, which is a great idea and one that I think will be of very real benefit to our country and our people.

I have a statement that I would ask unanimous consent to have inserted in the record in full.

The CHAIRMAN. It will be included in its entirety, and a statement submitted by Senator Simon for inclusion in the record also.

Senator PELL. And in addition, Mr. Chairman, I would hope that the witnesses—and I see some old friends amongst them—will expand upon their views a little bit on how far in science we should go. There are many phenomena that occur for which one does not find scientific explanations. And as some of the witnesses know, I have a great interest in this subject, and I hope they would develop that as well.

Thank you.

[The prepared statements of Senators Pell and Simon follow:]

STATEMENT OF SENATOR CLAIBORNE PELL (D,RI) AT THE HEARING ON
FEDERAL SCIENCE POLICY APRIL 6, 1989

At the outset, I would like to commend the Chairman for convening this hearing on the very important issue of science policy. Scientific research and development is critical to our survival as individuals, our survival as a people, and our survival as a planet. We have a central interest in promoting science research and education. The oilspill in Alaska is but one example of our dependence on science for solutions to increasingly complex dangers. We look to science to fight major epidemics such as AIDS, and we look to technological advancement to design new mechanisms for outdistancing the threat posed by the stockpile of weapons in other nations.

In addition, we have a major economic interest in scientific advancement. We spent considerable time last Congress to enact a bill that would strengthen our trade preparedness in the international marketplace. Throughout that debate, the clarion call to expand and support scientific research and education was sounded time and time again.

It is abundantly clear that our investment in science does not match the considerable stake we hold in its promotion. In the area of education in particular we are woefully behind. A recent study by the National Assessment of Educational Progress indicates that when compared to other nations, the U.S. ranked in

the middle in science achievement at grade 5. By grade 9, the U.S. ranked next to last, and in the upper grades of secondary school, "advanced science students" ranked last in Biology and close to the bottom in Chemistry and Physics.

It is clear that the higher the grade level, the greater becomes the discrepancy in science literacy between our country and competitor nations. A national science policy therefore needs to begin with quality science instruction in the early grades. Since 1984 with my introduction of the Education for Economic Security Act, I have called for a massive upgrading of instruction in mathematics and science in our elementary and secondary schools.

We called for full funding of this program in the Omnibus Trade Act, and we reauthorized this critical program in the recent elementary and secondary education reauthorization act. The real flaw of this program is insufficient funding. It is my hope, therefore, that any major statement on science policy . . . from the executive branch or the legislation branch . . . would include a call for a significant increase in our elementary and secondary schools math and science program.

I hope that our witnesses will address this issue and am eager to hear their thoughts in this regard.

Senator Paul Simon
Senate Labor and Human Resources Committee
Federal Leadership in Science
April 6, 1989

Mr. Chairman, I am pleased to join you in welcoming this most impressive group of witnesses. I would like to thank them for taking the time to address the importance of strong federal leadership in science.

The leadership the federal government provides in the area of science and technology will have a profound impact on the future direction of this country. Such areas as economic development, international competition, environmental protection, military security and public health are directly affected by scientific and technological developments. In fact, it is difficult to think of any area of our daily existence that is not affected by some aspect of science and technology.

I was encouraged by President Bush's campaign promises to give high priority to science and technology and to make a science advisor part of the cabinet. The fact that science initiatives are a prominent part of the Bush FY 1990 budget proposals seemed to assure that a strong and high level science

advisor would be appointed promptly. I am sorry to say that this has not been the case. The Administration has offered us little leadership in the development of science priorities and leadership is sorely needed.

As a member of the Budget Committee I know how difficult it is to work out the details of a budget. It takes strong leadership and an understanding of national priorities and goals. The same type of leadership is necessary in charting the national goals in science. Policy makers must be able to respond with flexibility to scientific breakthroughs such as the development of the Superconductor Supercollider or the sudden need for a scientific solution to a public health crisis, such as the AIDS epidemic.

At the same time, we need to ensure continuing support for important basic sciences, science education, academic facilities, and other basic needs to strengthen our scientific base. In times of scarce budget resources, critical federal leadership in the area of science and technology is not a luxury - it is a necessity.

We must acknowledge the critical role that federal support for science and technology plays in determining our Nation's future competitiveness and quality of life. An important first step in

this acknowledgement is the appointment by the President of a high level science advisor. However, one advisor cannot do it alone. We need leadership in the Congress and we need leadership in the field.

I look forward to hearing the views and suggestions of the leaders in the scientific community assembled here today.

The CHAIRMAN. Senator Pell, I mentioned informally before we started the meeting that we are going to hear about some of the broad national needs in terms of science and technology and where we ought to be going. I hope that—and I urge your involvement—as we look at our reauthorizations and appropriations, and the Budget Committee, that they might be able to guide us as well, not only on the particular programs which deal directly with these issues, such as the National Science Foundation, but also some of our other reauthorizations as well in areas of education, training and other programs.

I think, given the scarce resources, we have to be realistic in terms of what is going to be available for just a few of the items that I mentioned here this morning: in terms of developing the additional resources for research facilities, university-based, and other types.

We are trying to restore and upgrade university research facilities; but we know we are going to be facing scarce resources, and as far as I am concerned, I would like to see movement of resources from other areas into these. But I would hope we could gain their insight into how we might be able to use even the existing resources a good deal more effectively.

We welcome this morning Dr. Press, currently President of the National Academy of Sciences. Before taking that post, Dr. Post was the Science Adviser to President Carter. For many years, he was Chairman of the Earth Sciences Department at M.I.T. He has appeared before this committee on many different occasions and is a good friend. I want to welcome you back.

Also, Dr. Guyford Stever, who was Science Adviser to President Ford, and also a faculty member at M.I.T., President of the Carnegie Mellon University, and Director of the National Science Foundation.

We look forward to hearing from you gentlemen.

Dr. Press?

STATEMENTS OF DR. FRANK PRESS, PRESIDENT, NATIONAL ACADEMY OF SCIENCES, WASHINGTON, DC; AND DR. H. GUYFORD STEVER, FORMER PRESIDENTIAL SCIENCE AND TECHNOLOGY ADVISER

Dr. PRESS. Thank you, Mr. CHAIRMAN.

It is a pleasure to appear before a committee that, under your leadership, not only has nurtured the premier research agencies of the Federal Government, but also helped design a framework for science and technology policy in the United States. I refer to the National Science and Technology Policy, Organization and Priorities Act of 1976, a product in part of your efforts and those of this committee, with considerable assistance from my colleague Guy Stever.

I suspect that the testimony you will hear today will confirm the wisdom and flexibility of that legislation. In many respects, we will be talking about the fulfillment of its promise rather than a need for changes.

This is quite remarkable in view of the rate of scientific advance on nearly all fronts in the last decade and a half as well as less

encouraging developments such as the relative decline of the U.S. position in the world economy, which you mentioned, of course, in your opening remarks.

Today that relationship—between a flourishing international scientific and technical enterprise and a troubled domestic economy—is at the heart of concerns about U.S. science and technology policy, the role of STP, and the qualifications and status of the President's science and technology adviser.

The challenge before the Bush Administration is to accomplish a better integration of science and technology and economic policy in all its macro and micro manifestations—monetary, tax, budget, trade and regulatory policy.

This morning I want to discuss one aspect of that challenge—the setting of science and technology funding priorities in an era of budgetary restraints.

Although I addressed this problem—what I called the “Dilemma of the Golden Age”—exactly a year ago in a speech before the Academy of Sciences that received considerable attention, my comments today reflect deliberations over several months by groups within the Academies of Science and Engineering and the Institute of Medicine. These deliberations were part of an unusual effort on our part to help the new Administration and Congress make progress on a few issues of national importance involving science and technology by producing succinct statements of our technical understanding and judgments about promising policy directions.

In addition to global environmental change and the AIDS epidemic, our “White Papers” addressed the role of science and technology advice in the White House and a framework and procedures for setting science and technology budget priorities.

This latter effort few out of an explicit request to the Academies by the Senate and House Budget Committees, contained in the conference report on last year's budget resolution.

Because Guy Stever had a profound influence as a participant in both studies, the two of us have taken the liberty of dividing our labors this morning. With the committee's permission, Dr. Stever will discuss general aspects of scientific and technical advice in the White House, drawing on our “White Paper”, as well as his service on the Carnegie Commission on Science, Technology and Government.

I want to summarize the main points of our report, “Federal Science and Technology Budget Priorities.” Both appear in a single volume, which I would like to submit for the record.

Our report contains three types of recommendations. First, we propose a framework for guiding Federal science and technology budget preparation and assessment. Second, we suggest a set of criteria in the form of questions that can be helpful in judging whether allocations for science and technology resources are serving national objectives. And third, we recommend feasible changes in the Executive Branch process of preparing science and technology budget proposals and in the Congressional process of reviewing Administration requests and appropriating funds. I will review briefly each set of recommendations.

First, a framework for assessing science and technology budgets. It is important to examine proposed expenditures for science and

technology in relation to the national purposes they serve. We suggest four categories. These categories are not mutually exclusive for the obvious reason that most science and technology efforts are intended to serve more than one purpose.

The first, science and technology activities supporting sponsored agencies' missions. Most agencies use science and technology to enable them to discharge their missions. These are basic governmental functions serving the national welfare.

Current budget processes and organizations do reasonably well in assessing the mix, level and quality of science and technology in relation to an agency's other activities and deciding resource allocations accordingly.

Second, the maintenance and advance of the Nation's science and technology base. Achieving national and agency objectives from adequate growth to an adequate defense depends in the long run on the education and training of talented people, the production of new knowledge through research, and the provision of related facilities and equipment—what we commonly refer to as the Nation's science and technology base. Maintaining and improving this capacity are responsibilities of several agencies; but in the current budgetary process, little attention is paid to the contributions of any agency or to the adequacy of the investments in the aggregate in replenishing science and engineering manpower and infrastructure.

The third category is activities, usually of several agencies, that contribute to broad national objectives of the President or Congress or both.

Recent experience suggests that an increasing share of these objectives will have prominent science and technology components—for example, industrial competitiveness and global environmental protection—and that the support of relevant science and technology frequently is disbursed among many agencies.

The formulation of science and technology budgets in these areas should entail review and judgments about the respective role of the agencies involved, the relative contributions of science and technology, and the issues to be addressed by science and engineering.

And finally, major and costly science or engineering initiatives that require very large incremental expenditures. From time to time, scientific or technological opportunities arise that require very large expenditures over a number of years. Examples are the Superconducting Super Collider; the project to map and sequence the entire human genome, and the space station.

Projects of this sort will fall in one or more of the above three categories, and their priority should be judged primarily within those contexts. For example, the utility of the space station depends primarily upon how the Nation's political leadership defines America's objectives in space and in particular the role of manned space exploration.

Because of their complexity, costs and multiyear commitments, these large projects impinge on the funding of activities in other categories and therefore merit special analysis. It is especially important that future outlays for all of these large projects receive systematic review.

In the second part of the report, we consider what changes in the budget process are needed to make use of the framework and how to achieve these changes——

The CHAIRMAN. Dr. Press, I want to hear you out, but I would hope that all of our witnesses this morning—who are all very distinguished and prominent individuals—would be able to really target and summarize their testimony. We will put all the statements in the record in their entirety.

But so far, what I have gotten from you is that we need a careful budget evaluation of different scientific research. I do want to hear you out; but do you want to highlight at least the principal areas. As the principal figure of the National Academy of Sciences—it has got to be more than the first six pages of your testimony, quite frankly, that we need a careful budget evaluation of these major projects—or am I missing something?

Dr. PRESS. Why don't we put my testimony in the record, and I will just talk informally.

The CHAIRMAN. Oh, yes, we will put it all in the record.

[The prepared statement of Dr. Press follows:]

STATEMENT OF

FRANK PRESS

PRESIDENT, NATIONAL ACADEMY OF SCIENCES

BEFORE

THE COMMITTEE ON LABOR AND HUMAN RESOURCES

UNITED STATES SENATE

APRIL 6, 1989

Mr. Chairman, it is a pleasure to appear before a committee that under your leadership not only has nurtured the premier research agencies of the federal government but also helped design a framework for science and technology policy in the United States. I refer to the National Science and Technology Policy, Organization, and Priorities Act of 1976, a product in part of your efforts and those of this Committee, with considerable assistance from my colleague Guy Stever.

I suspect that the testimony you hear today will confirm the wisdom and flexibility of that legislation. In many respects, we will be talking about the fulfillment of its promise rather than a need for changes. This is quite remarkable in view of the rate of scientific advance on nearly all fronts in the last decade and a half as well as less encouraging developments such as the relative decline of the U.S. position in the world economy.

Today that relationship -- between a flourishing international scientific and technical enterprise and a troubled domestic economy -- is at the heart of concerns about U.S. science and technology policy, the role of OSTP, and the qualifications and status of the President's science and technology adviser. The challenge before the Bush Administration is to accomplish a better integration of science and technology and economic policy in all its macro and micro manifestations -- monetary, tax, budget, trade, and regulatory policy.

-2-

This morning I want to discuss one aspect of that challenge -- the setting of science and technology funding priorities in an era of budget constraints. Although I addressed this problem -- what I term the "Dilemma of the Golden Age" -- exactly a year ago in a speech to the Academy of Sciences that received considerable attention, my comments today reflect deliberations over several months by groups within the Academies of Sciences and Engineering and the Institute of Medicine. These deliberations were part of an unusual effort on our part to help the new administration and Congress make progress on a few issues of national importance involving science and technology by producing succinct statements of our technical understanding and judgments about promising policy directions.

In addition to global environmental change and HIV infection, our "White Papers" addressed the role of science and technology advice in the White House and a framework and procedures for setting S&T budget priorities. The latter effort grew out of an explicit request to the Academies by the Senate and House Budget Committees, contained in the conference report on last year's budget resolution. Because Guy Stever had a profound influence as a participant in both studies, the two of us have taken the liberty of dividing our labors this morning. With the Committee's permission, Dr. Stever will discuss general aspects of scientific and technical advice in the White House, drawing on our White Paper as well as his service on the Carnegie Commission on Science, Technology, and Government. I want

to summarize the main points of our report, "Federal Science and Technology Budget Priorities." Both appear in a single volume, which I submit for the record.

Our report contains three types of recommendations. First, we propose a framework for guiding federal science and technology budget preparation and assessment. Second, we suggest a set of criteria in the form of questions that can be helpful in judging whether allocations for science and technology resources are serving national objectives. Third, we recommend feasible changes in the Executive Branch process of preparing science and technology budget proposals and in the congressional process of reviewing Administration requests and appropriating funds. I will review briefly each set of recommendations.

A Framework for Assessing Science and Technology Budgets

It is important to examine proposed expenditures for science and technology in relation to the national purposes they serve. We suggest four categories. These categories are not mutually exclusive for the obvious reason that most science and technology efforts are intended to serve more than one purpose.

1. Science and technology activities supporting sponsoring agencies' missions. Most agencies use science and technology to enable them to discharge their missions. These are basic governmental functions serving the national welfare. Current

budget processes and organization do reasonably well in assessing the mix, level, and quality of science and technology in relation to an agency's other activities and deciding resource allocations accordingly.

2. The maintenance and advancement of the nation's science and technology base. Achieving national and agency objectives -- from economic growth to an adequate defense -- depends in the long run on the education and training of talented people, the production of new knowledge through research, and the provision of related facilities and equipment -- what we commonly refer to as the nation's science and technology base. Maintaining and improving this capacity are responsibilities of several agencies; but in the current budgetary process, little attention is paid to the contribution of any single agency or to the adequacy of investments in the aggregate in replenishing science and engineering manpower and infrastructure.

3. The activities, usually of several agencies, that contribute to broad national objectives of the President or Congress or both. Recent experience suggests that an increasing share of these objectives will have prominent science and technology components -- for example, industrial competitiveness and global environmental protection -- and that the support of relevant science and technology frequently is dispersed among several

agencies. The formulation of science and technology budgets in these areas should entail review and judgments about the respective roles of the agencies involved, the relative contribution of science and technology, and the issues to be addressed by science and engineering.

4. Major and costly science or engineering initiatives that require large incremental expenditures. From time to time scientific or technological opportunities arise that require very large expenditures over a number of years. Examples are the Superconducting Super Collider, the project to map and sequence the entire human genome, and the space station. Projects of this sort will fall in one or more of the above three categories, and their priority should be judged primarily within those contexts. For example, the utility of the space station depends primarily upon how the nation's political leadership defines America's objectives in space and, in particular, the role of manned space exploration. Because of their complexity, costs, and multiyear commitments, these large projects impinge on the funding of activities in other categories and therefore merit special analysis. It is especially important that future outlays for all large projects receive systematic review.

Building on the Current Process

In the second part of the report we consider what changes in the budget process are needed to make use of the framework and are possible to achieve. In our judgment, the current budget process provides for reasonably thorough consideration of the contributions of agency science and technology programs to agency objectives ranging from advances in weapon system capabilities and health care to technical standards development and agricultural productivity. We do not propose that this decentralized approach be fundamentally changed, for it has contributed not only to a variety of government missions but also to the strength of the U.S. science and technology enterprise as a whole. Indeed, countries with highly centralized research systems have shown growing interest in emulating our pluralistic system.

Nevertheless, we believe that improvements can be made in both the executive and congressional phases of budget preparation and review, especially for those categories of purpose that involve the contributions of several agencies and span the jurisdictions of several congressional committees.

We propose that the President provide the agencies with guidance on crosscutting S&T budget considerations early in the budget cycle. Such guidance is now lacking. This will enable agencies to respond more effectively to both their mission needs and the broader

national priorities that are the concern of the President. This guidance can be used by others -- OMB, Congress and its support agencies, and affected interests -- to assess agency proposals in relation to the President's priorities.

We envision that the President's Science and Technology Adviser will work closely with OMB to prepare both the guidance and the evaluations. The Council of S&T advisers favored by President Bush would be one way to involve the scientific and engineering communities, along with the S&T Adviser's direct personal contacts with broad elements of the community. For example, the guidance recommended to and issued by the President might emphasize support of graduate training in the physical sciences and engineering or the advancement of generic manufacturing technologies or research on global climate change or exploration of long-range applications of high-temperature superconductors. This guidance, together with an analysis of how it is reflected in agency budget proposals, should accompany the President's budget submission to Congress.

If the President's budget preparation and presentation follow these recommendations, Congress will receive an explicit statement of the administration's S&T priorities. Budget allocations for related science and technology programs across agencies will be displayed. Congress will then have more information than it currently obtains as a basis for evaluating the President's priorities.

For the process to be effective, Congress should make complementary adjustments in its budget process. In particular, Congress should devise arrangements enabling it to consider the proposed science and technology budget allocations as they relate to the crosscutting categories of purposes before the budget is disaggregated for consideration on an individual agency basis. It is therefore an appropriate function of the Budget Committees, the authorizing committees with broad S&T oversight jurisdiction, the Appropriations Committees, or some combination of these committees. In any case, recommended changes in the President's budget proposals need to be communicated to the Appropriations subcommittees so that they will be aware of the broader consequences of their actions on individual agency budgets.

We also endorse a two-year funding cycle. If Congress decides to experiment with biennial appropriations rather than to move all at once to a two-year budget, we believe that S&T programs should be leading candidates for such a trial.

The National R&D Investment

Finally, I want to bring to the Committee's attention an issue in our deliberations that confuses the true nature of the federal government's R&D investment, which as usually defined exceeds \$67.0 billion in the FY 1990 proposed budget. That issue is the treatment of DoD R&D activities in national R&D statistics.

Combining the entire DoD R&D budget with the R&D activities of the civil agencies in an uncritical manner may overstate the magnitude of the nation's science and technology effort. Basic and applied research in DoD are similar to civilian agency S&T activities. The great bulk of what is now identified as DoD R&D, however, is directed toward specific military equipment development, testing, evaluation and prototype procurement and is not comparable to other federal S&T activities. Under these assumptions, the actual federal R&D investment is probably closer to \$40.0 billion. We believe that the administration should convene a group of experts to clarify the extent to which DoD R&D activities are comparable to civilian R&D.

Conclusion

There have been some encouraging developments since we released our budget report in December. We have met with a number of officials in the Executive Branch, including the director of the Office of Management and Budget, and with several members of Congress. We believe that our perspectives on the crosscutting nature of many federal science and technology activities and the need to evaluate them throughout the budget process have begun to influence or reinforce thinking in the Executive Branch. These points are reflected in both the Reagan and Bush Administration FY 1990 budget submissions to Congress.

For example, the "Special Analysis on Research and Development" in President Reagan's budget message states:

...Most Federal R&D is done in direct support of agency mission needs. Most agencies have a well-defined process for establishing their R&D priorities.... However, there are cases where R&D activities cut across several agencies, or where R&D projects are of such a magnitude as to force choices either within or between agencies.... The Executive budget formulation process has focused on specific areas for crosscutting reviews....

Reiterating this theme in his budget statement, "Building a Better America," President Bush promises that the Office of Science and Technology Policy

... will play a central role in developing and coordinating Federal science and technology strategies, and in analyzing crosscutting issues in research and development. The Assistant to the President for Science and Technology (will) also assist the Office of Management and Budget in developing plans for multi-year authorizations and appropriations for research and development programs....

We are encouraged by these statements and hope that more concrete steps will follow along the lines I have outlined this morning. The Academies are not content simply with having prepared and presented this report. We hope to work with the the Executive Office, the agencies, and the responsible committees of Congress to make real improvements in federal budgeting for science and technology.

(Note: Due to printing limitations, and in the interest of economy, a publication entitled "National Issues in Science and Technology", printed by the National Academy Press and accompanying this statement, was retained in the files of the committee.)

The CHAIRMAN. Quite frankly, from the first five pages, what I am getting so far—the Space Station; we have got to evaluate it, look at it, see whether we need it and is it under our priorities. We have a major crisis, and you are the major person, as I understand it, who ought to be guiding us as to where we ought to be going. And we have got to do better, I think, than talk about how we evaluate different kinds of questions, it would seem to me.

Am I missing something? I may very well be.

Dr. PRESS. Let me respond to that.

I do not have to tell you or this committee the importance of science and technology to this Nation's future; you can see it on the charts that you have posted here. Both charts show that we have quite a problem in front of us.

At a time of severe budgetary constraints, where we have very major problems to worry about, we have to make sure that the allocation of our resources for science and technology and education are optimal, that they do the jobs that they are supposed to do.

In our budget allocation procedures over the years, we have developed a system that is decentralized, that is agency by agency, that never takes into account the aggregate impact of the entire Government on such issues as competitiveness, as infectious disease, as improving agriculture for the next generation, less polluting, less environmentally-damaging agriculture—the host of issues that the Nation has to address.

So we are proposing a budgetary process and a framework for analyzing the budget so that these national needs can be met. That is the gist of our report, and that was the gist of my testimony.

The CHAIRMAN. It is clearer to me now. Basically, as I understand it, you are saying I suppose, that the Adviser to the President on Science, ought to coordinate each of these areas in terms of the budget allocation, in terms of national objectives.

Dr. PRESS. And that is the heart of our recommendation, a role for the Science Adviser in the White House, to view the entire perspective of science and technology and its economic impacts and to advise the President from a very influential position about the optimal allocation of resources to meet these national needs. And that is an essential part of our framework.

But that is not enough, because if Congress receives such a budget, analyzed and prepared in this way, it cannot immediately disaggregate it and send it to all of the separate subcommittees and break it apart without looking at it as a whole. And the second part of our recommendation was for a Congressional procedure to receive the entire budget and to look at it in aggregate to see its national impact.

The CHAIRMAN. Like the "State of the Union" concept, which in a general way does it, for the economy, we ought to try and do it with regard to where we are in terms of scientific investment; is that it?

Dr. PRESS. We were very happy with the President's State of the Union opening address, in which he elevated the position of the Science Adviser and, in fact, used some of the language in our report in putting his statement together. But of course, we are awaiting with great anxiety the appointment of a very capable, experienced Science Adviser to fulfill those promises.

The CHAIRMAN. I gather without the kind of focus that would come from the President's Science Adviser, it is scattered, and it is not prioritized—that is a reasonable assumption, I imagine. Speaking for the Academy—but also as a former Adviser to a President—how do you reach that determination, and what priorities do you think indicate the areas of greatest need?

Dr. PRESS. Let me describe the way the process has worked in the past. I know you are concerned about education. Let us say that you feel there is a national shortage—there will be a shortage of scientists and engineers in the years ahead. That is actually the case. There is no way in the present budgetary process for you to find out the total impact of the United States Government in addressing this issue, because that function, the training of people, is distributed among half a dozen agencies. And in our process, we want the Science Adviser, working with OMB, as a senior member of the White House staff, to address that issue, for example, across all of the agencies.

Or, if you are concerned about the environment, issues of environment fall across half a dozen agencies also, with separate budgets, never aggregated, never analyzed for their total impact.

So I don't believe we are getting as much out of our funding today as we should get without this coordination and without this understanding, and that is the key role of the White House Science Office—that should be its role in the years ahead.

The CHAIRMAN. That makes it a lot clearer, at least for me.

Dr. STEVER, would you like to proceed, and then we will come back to some general questions.

Dr. STEVER. Mr. Chairman, Senator Pell, thank you very much.

You do remember the decade and a half ago, putting together the Act of 1976 on which the White House structure for science is based. As I look at the age of many of your staff, I would recommend that they go back and read that to see how well an act can be put together. Today that Act does not have to be changed; all it has to do is to be implemented. In fact, we need it more today than we needed it then.

As Frank Press said, the outlook is——

The CHAIRMAN. I do not know how Ellis Mottur feels; he looks a little older to me——

Dr. STEVER. He is the exception.

The CHAIRMAN. We brought him back out of the field to give us a little guidance here, and he said there is nothing wrong with that Act. He should know since he was my principal helper and staff-person in drafting it and pushing it through to enactment.

Dr. STEVER. He is the exception that proves the rule about the age that I see here.

I would like to point out that as these years have gone by, we have suddenly gotten a much deeper understanding of the Presidential needs in this area. It is not a job simply that works on purely scientific and engineering matters, although that is important, too, the National Foundation budget, the research budget at NIH and so on. But the range of issues has expanded that should come under his purview, and also the depth to which science and technology is needed. I will just list them quickly.

The international security arena; weapon systems, ever more complex, conflicting claims about their feasibility and their performance; the interdependence of the industrial base of our country between military and civilian, where a very serious thing is occurring. We should note it and adjust to it, and that is that today, the civilian economy and innovation in science and technology is running ahead, often, of the military sector, and we have got to adjust there.

Arms control depends more and more on the scientific/technological basis of verification.

There is another thing that is emerging very quickly on our scene, and that is the whole effect of globalization, globalization of everything. People talk about the globalization of industry. To a considerable extent, it is brought on by the fruits of technological labor in the transport of people and in the transport of information across the seas. But this globalization brings on two kinds of things for our country in the use of its science and technology. There is the area of international cooperation, and counter to that there is the international global competition. And we have to adjust somehow to that yin and yang of the international scene on science and technology.

In cooperation, you certain know that we believe in collaborating; we believe we should exchange basic science and technology research results, and we make agreements to do so. We at the same time need to make sure that our intellectual property is protected and that we have a fair shake in the global competition.

But in domestic social services arena—health, of course, you know very well, so I will not speak very much there—the environmental area—you know, we talked about environment back in those days, 15 years ago, but I want to tell you it is a different scene today. It has gone international so fast that we are having a hard time to adjust to it.

Right now our Federal Government has a very difficult time even putting together the positions for our leaders to take to international conferences. We have a major job of straightening out the international environmental arena and the way we get our basic policies and the way we exchange information—and most important, what we do about it. We have spent a lot of time figuring out what the problem is, but very, very little time on what we really do. And suddenly, the world is waking up to that.

With respect to this position in the White House, I said that the act did not have to be changed, it only had to be implemented.

There is one interesting change that a number of people have spoken about, the Academy paper, and so on, and that is to upgrade the position to a Presidential Assistant. The Carnegie Commission took the direct step to make him the President's Assistant for Science and Technology, to drop the Science Adviser title completely, and then really give him functions to do—advice, policy participation; funding, Dr. Press has spoken about; implementation, that is, tracking the implementation of science and technology, and giving him early warning and telling him how well his policies are being followed.

I would just conclude by pointing out that I think if we really can get the kind of person we want—and you have already pointed

out it should not be a politically motivated person; we would also like to point out that we don't need necessarily simply a skilled scientific expert, solely that, but we would certainly like somebody from the community of science and technology who is gifted and knows our ways and our people and our institutions.

But there are four associate directors in the OSTP, and those jobs have never been capitalized on. If we had an assistant to the President or a Science Adviser to the President, with four topnotch associate directors and an improved staff, we would be in a very powerful way to get involved in the policymaking in the White House, I believe.

There is one issue that has to be faced, and that is how the White House gets its outside help, non-government employment. I would point out that there was Peace Act, which a lot of people thought was very good; it had some weaknesses with respect to some political views. But every President has recognized sooner or later that he needed an organization of outside people to come in to help him and his Science Adviser in performing the job in the White House.

Well, Mr. Chairman, I have participated in some studies at the Academy on the space program, on which I am prepared to talk. I have participated also in the Academies of Engineers in engineering international cooperation in engineering technology, and I would be glad to answer questions there, although I do not have it in my testimony.

Thank you.

[The prepared statement of Dr. Stever follows:]

STATEMENT OF
H. GUYFORD STEVER
FORMER PRESIDENTIAL SCIENCE AND TECHNOLOGY ADVISOR

BEFORE THE
COMMITTEE ON LABOR AND HUMAN RESOURCES
UNITED STATES SENATE

APRIL 6, 1989

Mr. Chairman and members of the Committee, thank you for the invitation to present these ideas on the important subject of science and technology advice to the President. As Dr. Press indicated, for my remarks I will draw on the White Paper, "Science and Technology Advice in the White House," recommendations for President-Elect George Bush made by the National Academy of Sciences, the National Academy of Engineering and the Institute of Medicine.

Thinking back a decade and a half, you will vividly recall the work of President Ford and several committees of the Senate and the House, including yours, to ensure the birth of the National Science and Technology Policy, Organization, and Priorities Act of 1976. It was greatly needed then and even more so today. There is a widely held view that the nation is by no means getting the full value of that very well conceived Act. The beauty of the Act is that it needs no more than vigorous implementation to secure an excellent base for handling the Federal Government's responsibilities at the top. Over the years support for strengthening the White House science and technology capabilities has grown from well beyond the professional science and engineering groups to include strong statements from industrial, academic and other leaders.

The outlook is excellent; on February 9th, in his Budget

Message to Congress, "Building a Better America," President Bush stated that he would make his Science and Technology Advisor an Assistant to the President, a promised step that has been applauded by our community. It is clear that steps must be taken to enhance the position if it is to attract a person of the desired caliber. In the covering letter to our Academies' White Paper, our Presidents gave these three major attributes for the appointee: "a commitment to the success of your presidency and an ability to work effectively with other senior advisors on whom you will depend; outstanding scientific or engineering credentials that command the respect of the industrial and academic communities and parts of the bureaucracy whose help you will need; and familiarity with influences on the federal role in science and technology and with the political environment of the Executive Branch." The appointment of a pure technician, a constituency advocate, or a political partisan would defeat the utility of the position. We expectantly await the appointment of a well qualified person.

In the several decades of scientific advice to presidents, a much deeper understanding of presidential needs has developed. Clearly, the job is a complex one encompassing not only solely scientific and engineering matters, but including a wide range of issues in which scientific, engineering and technological considerations meld with many other factors. This range of issues is expanding. For instance, here are a number of the

issues facing the President in which there are major scientific and technological aspects:

*In the international security arena--weapons systems are evermore complex and are subject to conflicting claims of technical feasibility; the Strategic Defense Initiative needs reconsideration; the interdependence of the industrial base between the military and civilian applications is changing, with the lead in innovation and development shifting from the military to the civilian sector; arms control depends increasingly on verification technologies.

*In the international cooperation arena--the terms of trade in technology-based products and services involve rules for restricting for national security reasons or encouraging for commercial reasons; collaboration and sharing scientific results among countries have advantages but are complex in arrangement; the global environment needs special attention in preventing or alleviating adverse changes and/or adapting to them.

*In the global competition arena--steps must be taken to improve our national technology base and protect our intellectual property of that base; our science and engineering talent pool must be increased and the quality of education in science, mathematics and engineering must be raised; the federal governments strengths in research and development must be

marshalled to aid in the strengthening of our industrial competitiveness; and government's power to establish a favorable climate for industry in this competitiveness race must be used.

*In the domestic social services arena--the challenges are indeed complex, for example, in health where the government has responsibilities in allocating major resources to basic research for incorporating technological advances into health care delivery, and monitoring the providers of health care.

*In the domestic environment arena--waste disposal of all kinds - chemical, nuclear, hospital, and domestic trash - has become a major problem, particularly as it affects our water, shared by all levels of government; the effects of human activity on the quality of our air, particularly as a result of chemical emissions and energy production by burning fossile fuels, forces the federal government to supply the research and development to understand the phenomena and to regulate the polluters.

How can a White House Science and Technology establishment go about doing it a job? The Carnegie Commission on Science, Technology and Government makes the direct recommendation to change the title from President's Science and Technology Advisor to Assistant to the President for Science and Technology, thus dispelling the notion that the job is simply advisory. In such a position, the Assistant wears two hats, one as a senior member of

the White House staff, and the other as the Director of the statutory Office of Science and Technology Policy. In each of these capacities the Assistant should work with the OSTP staff and outside professionals as consultants in performing these functions:

Advice: advising and assisting the President and his staff;

Policy: participating in the formulation of policy involving S&T;

Funding: advising on the priorities and funding of S&T;

Implementation: tracking the implementation of S&T related policy;

Early Warning: alerting the President to developments in S&T and their policy significance;

Emergencies: responding to emergencies such as electricity blackouts, technoterrorism, computer breakdown, natural disasters.

In working with other senior members of the President's staff and Cabinet members in their work on the various councils, there are some who would have the Assistant become a member of

the councils; others would be satisfied with a close and formal relationship with plenty of evidence of effective cooperation.

If the 1976 Act were fully implemented by appointing four Associate Directors of the OSTP, the Assistant to the President could have a powerful team working with him in carrying out all of his functions. By careful choice of appointees to these posts with fields of expertise in the sciences most required by the White House councils, the S&T Assistant would be exceptionally well prepared for close cooperation. If the rest of the staff were enlarged over that of recent years, and picked for quality, the OSTP could be a mighty force.

Finally, securing the best of outside S&T advice for the White House has been accomplished in several different ways over the past several decades. Each President has had the choice of the form which would fit his style. There are clearly some advantages of legislating it into existence in a particular form, something like the earlier President's Scientific Advisory Committee which was found to be very effective by several presidents.

In conclusion, I hope that President Bush soon has in operation a powerful, effective White House science office.

The CHAIRMAN. Thank you very much.

We will rotate back and forth and follow a ten-minute rule.

To both of you, given the changes that Dr. Stever has mentioned and which we would all acknowledge indicate a wide range of needs in terms of advances in science and technology and research, and given what you have said about the existing legislation, do I understand you to say that the legislation that is in place now is adequate—even with the challenges that we are facing—if it is fully implemented?

We'll start off with that.

Dr. PRESS. Well, I think so. I think it is mostly in the implementation. The President by Executive Order can elevate the Science Adviser as an assistant; can give him authorities and incorporate him in decisionmaking.

I would like to see the budget of that office increased. The staff has been emasculated and the budget reduced enormously; that has to be attended to. But I do not think it requires new legislation at this time.

The CHAIRMAN. Dr. Stever?

Dr. STEVER. I agree with that.

The CHAIRMAN. Okay. Now, given the appointment of Science Adviser with good access and a good working relationship with the President, what would you say, Dr. Press and Dr. Stever, if you were adjusting those priorities, beyond assuring that you are going to have a coordinated policy with regard to the various agencies that is in the national interest—and putting aside the budget restrictions—where do you believe it is most important in terms of the national interest, whether it is in the areas of national security or competitiveness, where do you believe we ought to be placing the higher priorities?

Dr. PRESS. May I start, and then Dr. Stever?

The CHAIRMAN. Surely.

Dr. PRESS. I think that our country faces a new form of international security. I think as we enter a new decade and a new millennium, the international security issues will not be weapons, will not be war—I hope that is the case. Certainly, we are making very rapid progress these days between the superpowers.

I think the new international security issues will be economic; there will be global environmental issues, energy, the health and welfare of people everywhere, because without attention to these issues, I think there will be dislocation, there will be unrest, and there will be a new form of a lack of security.

So increasingly, I think this requires the attention not just of scientists and engineers and physicians, but planners of all kinds, those concerned with the environment, with the economy and with everything else. And I think this has to be reflected beginning these next few years in budgetary allocations.

But in order to realize the full benefit of science in addressing some of these issues, we have to worry about the pipeline of scientists, the training of new scientists and engineers, the equipment in our universities, the facility, and we have to worry with as much importance as anything that I have said about the education of the American people, the education of our work force in the years ahead.

We can have the world's leading scientific Nation and an illiterate, uneducated work force, unable to enjoy the jobs created by science and technology. So I think these are where the priorities should rest in the years ahead.

Dr. STEVER. Senator Kennedy, I am scared. I have associated a great deal with Frank Press, and I suddenly realize that I am becoming cloned to him. Those were the two ideas that immediately popped into my mind when you asked your question.

One is a very long-range, tough question. The problem of improving our education is something that we have really got to lay out a policy for that is going to last for 10, 20 years. Money will help; changing attitudes; working on our people, the attitudes of families with respect to having their kids go into these fields. It is a big problem. But I will stand with those two points.

The CHAIRMAN. Let me ask you about biomedical sciences. There are some who believe that we are not providing the kinds of priorities in terms of the biomedical sciences, where there are great opportunities and extraordinary possibilities with the advances that we have seen in recent times.

Would you address that, Dr. Press and Dr. Stever?

Dr. PRESS. Well, the progress in the whole area of the biological sciences in the past quarter-century have been absolutely extraordinary, and they would not have occurred without the National Institutes of Health and with the great support by the U.S. Congress of the National Institutes of Health.

I believe that, although we do not have a cure for cancer, for example, the degree of understanding of the nature of cancer has progressed so rapidly in the past decade that it is really quite remarkable.

Without the advent of molecular biology, we would not even have identified the AIDS virus at this time and understand the directions we have to pursue to handle that dreadful epidemic.

The progress in such fields as child leukemia, coronary disease and so on, the understand of the connections between diet and health that have resulted from all of this is really extraordinary.

The future is still ahead of us. And then this field, this originally arcane field of molecular biology, has spawned a whole new industry of biotechnology, which most observers believe will be a hundred billion dollar industry before the end of this century, in a few years.

So I think that the potential is immense; it is there in front of us. We have to be concerned with some regulatory policies, with continuing the investments, but I think this is one of the peaks of this century's science, the progress in this field.

The CHAIRMAN. Dr. Stever, if I can just ask you an additional question, since our time is running rapidly out, as to the whole question of technology transfer. Could you address that? Where are we on the transferring of technology and making it more applicable and more readily available, and what should we be conscious of in terms of the development of a Congressional policy to try and assist this?

Dr. STEVER. Technology transfer has many different aspects. One, of course, is the transfer of work that is done essentially in Government laboratories to industry. I have always felt that we tended to

over-rate the possibilities there, although there are lots of possibilities, and I do believe that we are succeeding in making the agencies quite sensitive about making that work.

But I do believe in the end that the technology that is going to be important to us and our economic strength is going to rest in the hands of industry. So there, we have got to help them develop it; we have got to help them protect it when it is important to protect and to use it in their products and sell them overseas.

Dr. Press pointed out that there is this shift away from military toward economic factors in the international competition. I think we have to adjust to that and start using our technology a lot more in the commercial, non-military exchanges. I think we have lost a great deal there.

I also feel that you might look—and this is a tough one—you might look at how leaders of industry look at their technology. I have always felt that they sold it too cheaply. If a company develops a very important technology that it itself is not going to use, they will sell it for a song. I personally wish they would protect it a little more. But the mark of the future is going to be internationally, globally located industry. All of our largest companies essentially are becoming global industries, and they are going so far as to say we are a world industry that happens to have its headquarters in Detroit or Armonk or whatever. It is going to be a very difficult time to adjust to that control.

The CHAIRMAN. I just have time for one last question and that is, as I gather from what you have said, there is increasing concern or apprehension, perhaps, about the delay in selecting a Science Adviser to the President. Can you tell us what other Federal posts are essential in terms of our scientific enterprise?

Dr. PRESS. Depending upon how you reckon it, our Federal budget that supports science and technology amounts to about \$62 billion, and there are about 100 individuals across the Government in positions with major responsibilities in the allocation of these resources.

It seems to me that the Science Adviser should be in place early on before these positions are filled, to make sure that they are filled by the best-qualified people with the highest credentials who have the respect of the communities they have to serve and all of that.

So it is a disappointment that at this late date of an Administration, we do not have a Science Adviser in position, because that is a lot of money, and the impact, as you have said, is enormous.

The CHAIRMAN. Dr. Stever, is there anything you wish to add to that?

Dr. STEVER. I would just say if we are really going to look to our international competitiveness, I think we have got to strengthen the science and technology positions in the commerce area very much.

The CHAIRMAN. Senator Pell?

Senator PELL. Thank you very much, Mr. Chairman.

Incidentally, in connection with technology transfer, there is a provision under legislation I introduced in the Omnibus Trade Bill which authorizes for just \$3 million, a very little bit, for the Technology Transfer Act. As it is authorized it just needs a little push

to get it appropriated and established. So that particular structure is ready to go as soon as it gets some blood in its veins.

Many students in other countries spend far more days in the classroom than we do; as you know, half the year, 180 days, is vacation, and 180 days is study. What is your thought on that? Would you be in favor of an extension of the school year?

Dr. PRESS. I think we need a comprehensive program to address the problems of our schools, and that is one factor that certainly should be taken into account.

I would have to add to that the qualifications and training and salaries of our teachers, for example, are very, very important; the involvement of parents in education; national standards in terms of what we expect of our graduates from our schools.

Senator PELL. I could not agree with you more. Each of these is "desiderata"; but would you agree that amongst the "desiderata" would be an extension of the school year?

Dr. PRESS. I would support that personally, yes.

Senator PELL. Would you, Dr. Stever?

Dr. STEVER. Yes—although if we do not have good teachers handling that extended time, it is not so good.

Senator PELL. I agree; that would be assumed, and obviously, if the teachers, who also have half the year as vacation, had to only spend one-quarter of it, they should be recompensed accordingly on a proportional basis.

Another question I would like to address particularly to Dr. Press. Is your vision, or the vision of current science, in your view, broad enough to meet the demands of the endangered world in which we live—endangered from the viewpoint of human frailties, endangered from the viewpoint of damage from the machines and instruments we build.

Dr. PRESS. I see a lot of excellent proposals by very creative people who want to address those issues which are not being funded at the present time. So I think we are not realizing the full potential of science in addressing some of the issues that you are concerned with.

I say this, knowing that we spend more money as a Nation than the rest of all of those countries on that chart combined for science. And yet the returns of that marginal increase would be so enormous, calculated in any way, that I think it is worthy of serious consideration.

Senator PELL. Although, as Senator Kennedy mentioned in his opening statement, when it comes to the spending on civilian research and development, we stagnate at 1.8 percent, and our competitors, such as Japan, have grown to 2.8 percent and Germany to 2.6 percent.

Dr. PRESS. Yes, I agree with that, and that is part of my concern.

Senator PELL. Dr. Stever, would your views be parallel on that?

Dr. STEVER. Yes; I don't have anything to add.

The CHAIRMAN. Would the Senator yield?

Senator PELL. Yes.

The CHAIRMAN. On the point of the extension of the education, I do not know whether you have made any proposals on that. As I understand it—maybe the chairman of the Education Subcommittee would make a comment—most parents would like to have a

longer year, and yet when they are faced with it, they sort of back off it. That is what the general feeling is.

Although I was just in a school district down in Dade County, Florida where they are offering Saturday classes for Title I kids, and there is overwhelming success. The parents bring those kids in there, cannot wait to get them in there on Saturdays. This just ran completely contrary—and it is having an important impact. They are getting volunteer teachers to come in, and it has been very, very successful.

So I welcome Senator Pell's comments on this issue, and I agree with him, and whether we are going to have the courage to face up to it or perhaps offer some stimulus to see if we can get school districts to deal with it—whatever you can add to the answers on it, we would appreciate it.

Dr. PRESS. It is a very powerful argument for a parent to say, "Your child will be unqualified to take a job unless his education is improved along these lines, with these kinds of policies."

Dr. STEVER. I would like to add that in all my experiences with these various school programs, the good students leap at the chance of adding to the time that they spend, and that is very good. But we do have a major problem in a very large number of our workers in this country not getting enough education of any kind.

Senator PELL. I carry with me a little notebook with the amount of days that other countries spend in school—the Soviet Union, for example, 210; East Germany, 210; Thailand, 200; Canada, 190; and we spend 180. I think that those figures speak for themselves, and I would ask unanimous consent that staff be instructed to insert in the record at this point a comparison of the different school years in different countries.

The CHAIRMAN. So ordered—we are going to ask your staff to prepare it. [Laughter.]

[The information follows:]

**AVERAGE LENGTH OF SCHOOL YEAR FOR ELEMENTARY AND SECONDARY
EDUCATION (DAYS) OF SELECTED NATIONS**

<u>NATION</u>	<u>AVERAGE LENGTH OF SCHOOL YEAR (DAYS)</u>
CANADA	190
DEMOCRATIC REPUBLIC OF GERMANY	210
FEDERAL REPUBLIC OF GERMANY	165
FRANCE	185
ISRAEL	216
ITALY	213
JAPAN	243
MEXICO	180
SOVIET UNION	210
SWEDEN	180
THAILAND	200
UNITED KINGDOM	196
UNITED STATES	180

Source: Congressional
Research Service

Senator PELL. Speaking of staff, I might note that our staff has gray-haired people, too.

I have one further question. Japan graduates a little bit more the number of engineers than the United States, although it is one-tenth of our population. Do you see any dire results, looking down the road 10, 20 years, either one of you?

Dr. STEVER. I think that the rewards for Japanese engineers in employment in their society as a whole is very good, so it rates very highly with the families.

I am not so sure this is true in American families. Engineering and science are a little tougher subjects; you have to last a little longer in your educational period to qualify, and a lot of Americans shift away from it for other fields.

Senator PELL. I agree with you. I guess we have too many lawyers and too few scientists, and we ought to try to change the balance if we can.

Dr. STEVER. Well, I have many friends who are lawyers, so I hesitate to speak out.

Senator PELL. I do remember, though, happening to be in Moscow at the time Sputnik went up and seeing the people in the streets jumping up and down with excitement and waving newspapers and things. So science can excite a people, as it did then.

Dr. STEVER. It does.

Senator PELL. Thank you very much. I have talked too long.

The CHAIRMAN. Senator Jeffords?

OPENING STATEMENT OF SENATOR JEFFORDS

Senator JEFFORDS. Thank you, Mr. Chairman.

There is one area I would like to ascertain some information from the panelists on. A few years ago, the Northeast-Midwest Coalition, which I was a member of, held several hearings around the country with leading businessmen and educators. One of the serious concerns they had was the lack of adequate equipment and facilities for science. Not so much at the elite universities, but primarily across-the-board-type universities in this country.

As a result, I was able to get a token effort in the trade bill—\$50 million—so we now have an unfunded \$50 million program to help about one percent of the need—I think there is about a \$5 billion backlog.

How serious a problem do you think that is, and is it important that we spend more money or try to do something—I think that \$50 million program is with the National Science Program.

Dr. PRESS. Let me start. If you look at most of the recent breakthroughs in science, it is because of a new piece of equipment, an advanced piece of equipment that opens up a whole new field. That has been the case in the past, and it will be the case in the future.

I visit a lot of university laboratories, including not just the elitist, but many—many State universities, smaller schools—and both in the teaching laboratories for undergraduate education as well as in the advanced laboratories of our graduate students and our researchers, I sense that there is a very large backlog that still has to be filled, and the unfunded \$50 million could contribute, but I think we have to pay more attention to that in the years ahead as

moneys free up and as we solve some of our other deficit problems. But this should receive high-priority attention. It is the name of the game of scientific progress to have the best equipment available. That is what has held the Soviet Union back for all of these years. They have very smart scientists, and they are a third-rate scientific country because of lack of equipment. And we have to avoid that mistake.

Dr. STEVER. I would only add I hope that is extended to the lower grades, too; the high schools badly need help. I guess it has to come from the local school boards, but if somehow we can convince them that there is money available, that there is interest in it, they may respond.

Senator JEFFORDS. Thank you. I agree. It is discouraging to see how few go on to graduate school in these areas, and I would guess a contributing factor is the inability to get adequate training at both the secondary school and the university levels. If we are going to be competitive and to improve our edge, if we have one, in those areas, it seems to me we have got to provide those facilities.

Thank you, Mr. Chairman.

The CHAIRMAN. Thank you.

A good point that the Senator makes is that the Higher Education Facilities Act, which was started really in the Sixties, and by the end of the Sixties was up to about \$700 million, which would be about \$2 billion today, has effectively been eliminated, with all of the implications that both of you have commented on.

We want to thank you both very, very much. We appreciate very much your willingness to come and to help us and we are grateful to you for your advice. We want to thank you.

Our next panel is Dr. Hornig, who was a member of the Science Advisory Committee under President Kennedy, and then Science Adviser to President Johnson; after leaving that post, he became President of Brown University, and served as President of the Association of American Universities. He is currently Chairman of the Department of Environmental Science and Physiology at the School of Public Health at Harvard.

Dr. Branscomb is the Albert Pratt Public Service Professor at the Kennedy School of Government at Harvard. Before assuming that position, he was Vice President and Chief Scientist at IBM. He has also been Chairman of the National Science Board and Director of the National Bureau of Standards.

Both have appeared many times before our committee in the past, and we are glad to welcome back two good friends.

Senator PELL. Mr. Chairman, may I add a word here?

The CHAIRMAN. Please do.

Senator PELL. Thank you.

I just want to express my delight at seeing Dr. Hornig. I recall when he was nice enough to give me a degree and thank him very much indeed—an honorary one, but nevertheless, a very welcome one.

Dr. HORNIG. Thank you.

The CHAIRMAN. I am sure Dr. Hornig remembers that very special occasion.

Dr. HORNIG. It was a special privilege.

The CHAIRMAN. We are glad to have you both.

Dr. Hornig, we will start off with you, if you can—you might summarize, and then we've got some questions for you.

STATEMENTS OF DR. DONALD HORNIG, CHAIRMAN, DEPARTMENT OF ENVIRONMENTAL SCIENCE AND PHYSIOLOGY, SCHOOL OF PUBLIC HEALTH, HARVARD UNIVERSITY, CAMBRIDGE, MA, AND DR. LEWIS BRANSCOMB, ALBERT PRATT PUBLIC SERVICE PROFESSOR, KENNEDY SCHOOL OF GOVERNMENT, HARVARD UNIVERSITY, CAMBRIDGE, MA

Dr. HORNIG. Thank you, Mr. Chairman. I will try to be brief.

In the first place, I want to thank you for inviting me, because I think this is an important matter to tackle.

It is generally agreed that the American position has been eroding—sometimes this is overstated, but it really has been eroding.

Of course, what happens in science is, of course, only a part of the question of how our society performs, but it is an important part, and the Federal Government plays a critical role in that, because it is a major source of funding for research and development and, also, it is a source of both stimulus and sometimes of inhibition to our industrial efforts.

So the question of what the Federal Government should do, through what mechanisms it should be done, where the leadership and responsibility should be and how the priorities should be set deserve a hard look.

Well, this is not new. I think great credit belongs to Senator Kennedy, who took a leading part in the re-examination of all of these functions in 1976, when Public Law 94-282 was passed. I think the statement of goals there sort of includes everything that any of us can say.

Nevertheless, in the 13 years since, the world situation has changed, and we have had experience with how OSTP works under that charter. And in fact, it doesn't seem to have fulfilled what many of us had in mind, I believe, in 1976. Now, I don't know whether the problems lie in the way the President has used the office or in the structure and charter of the office, but in any case, the time is ripe to look it over again.

The first point I want to make, though, is when one looks at these problems, there aren't many quick fixes, and you should not just look at the question of the President's Science Adviser.

You asked about biomedical research and training. That, we spend about \$8 billion a year on, and that is carried on through the National Institutes of Health, and that is a broadly-integrated operation that includes research, training of students at the post-doctoral level, it includes faculty development, provision of facilities and instrumentation.

The Institutes in the past have always had their own communication channels to the White House and to the Congress, and OSTP and its predecessors played only a small part.

In the area of health research, I would say that NIH approximates the much-debated Department of Science. Within that area, it is a department of science, and in my view, it works pretty well, and it does so because relatively few matters overlap the interests of other agencies. And it provides in that area, I think, the kind of

leadership that we are looking for more generally in the scientific and technical area.

In juxtaposition, we have DoD; it has a \$42 billion R and D budget, and to the extent that it is focused on military matters, I think it poses no problems. It has a Director of Defense Research and Engineering to guide a really pretty tight management structure. But what we lack nationally, again, is a way of looking at these things from the outside. For instance, when you worry about arms control, when you worry about the impact of defense expenditures on industry and competitiveness, this you have to look at from the outside. And we do not know what the impact is on competitiveness. There is one school of thought which says that these military R and D expenditures are a stimulus to our high-technology industry; the other side of that coin is that it diverts people and resources.

We have examples of both. At the present time in electronics, I think the flow is from civilian industry into the military. If we take aircraft, I think the flow has been from military aircraft development into a very prosperous civilian industry. So this is not clear.

Well, without going over this agency by agency, we have a whole series of agencies which do important jobs, but since they all interact with each other, there has got to be a pilot for the ship somewhere and that, I think, is a real problem.

The CHAIRMAN. Is that the Adviser to the President?

Dr. HORNIG. I think that would be the main role of the Adviser to the President, yes—not to try to manage these things one at a time, but to help guide the whole—because in fact, although this arrangement, NIH, DoD, EPA, NASA, et cetera, is often criticized as fragmented, the fact is that everywhere, the way you get efficient performance is when the outcome is tied to what you do. So that within the areas of their own needs, I think this is the right way to do it.

I think, therefore, one of the things that we have to look at is to be sure that there are first-class people and good people in the research and development departments of each of these agencies, every one of them. It is very important, and it has been mentioned that in Commerce, we get a first-class under-secretary for technology—I am not sure whether it is "under-secretary" or "deputy secretary"—but at any rate, that there be a very good person.

As an aside, I should say incidentally when one talks also about how America does in the world, we have to worry about the fact that roughly half of the R and D is not funded by the Federal Government; it is funded by industry. And most of what the Federal Government funds, or a very large part of it, is carried out in industry. So that if we are looking at American leadership, we have to look at this industrial half. I am not going to devote any time to it today, but one really has to keep that in mind.

Well, so my first point is that aside from Science Adviser, we really have to worry about the quality of the people and the management in every one of the agencies.

Now, the trouble is there are some things which cannot be taken on one agency at a time, and I guess the major ones are, as has been mentioned, the supply of people, the supply of adequately-

trained people at all levels, from the people in the shops, who have to be able to read and write and handle very complicated machinery, on up to the very top levels of science.

Secondly, the conduct of basic research covers the whole spectrum.

And then thirdly, we need methods by which the whole science and technology enterprise gets coupled to the political decisions and political choices of the President and the Congress. That goes in both directions. It in some sense has to be responsive to what our national goals are; on the other hand, it has got to feed the decisions which are made, because very often, the decisions seem to be out-of-sync with what at least some people know and anticipate.

Now, as far as human resources are concerned, I think NIH has done a superb job. But when we look further, we do not know where to point out finger. No one has the responsibility to ensure that in our enormous school system, there is going to be enough science and mathematics taught so that we can feed our technical schools and our colleges and our universities. Nobody has the authority or the funds to secure sufficient scientific and technical education from kindergarten through high school to equip each child to participate as a citizen in a democratic society whose future depends on choices which involve scientific and technological common sense. I do not mean experts, but people have to understand the things they are voting for.

Now, I think this question ought to be taken on by the National Science Foundation. It had in the earlier days a superb record in, for instance, bringing high school teachers up-to-speed. It has more or less dropped out of science education, or at least backed off a great deal. But I think the time has come to really broaden its responsibilities to develop and push science education at all levels.

Basic research—my second thing—I think that is vested in the National Science Foundation. It was originally charged, before 1962, it was supposed to coordinate the basic research programs of all the Cabinet departments and agencies. It never did it, and of course, the reason was that in those days, it was such a pygmy amongst the giants that it was a little bit silly for it to try to coordinate DoD, for example.

Well, since then, its budget has grown 20 times; it has a director who understands industrial research; it has evolved a much bigger world view, and I think again that in this case, NSF should really be the locus for being responsible for the overall basic research programs and the strategy for basic research in relation to industry and our schools.

It should do in the rest of the natural sciences what NIH does in the biomedical sciences.

Now, the third general area I mentioned relating R and D to the political process, that has to happen, I think, around the White House; there is no other place, because the decisions have to be made on such matters as mentioned—SDI, acid rain, or the Superconducting Super Collider. And they have to be weighed in the context of all the other plans and commitments.

Now, I am doubtful that one can set up a grand coordinating and evaluating scheme, because as part of our processes, all these things have to be debated out with some scientific values and some

consideration of what else, maybe even nonscientific "what elses" we need to spend the money on instead.

But at any rate, there ought to be someone who is close enough to the whole White House apparatus, to the President and to the Congress, to bring these considerations in.

Naturally, NASA can bring in all the facts about the space station, I guess, and high-energy physicists can argue for the Super Collider—they all have an interest. So there has got to be somebody around and a mechanism around that does not have an interest.

Well, I think it doesn't depend on the formalities. I think that we need an organization which has a person there and people around who are strong, who command the respect of the other White House staff, because whether you appoint the person a special assistant or director of the office, I do not think that matters; the question is how much clout the person and the people around him has with the rest of the staff.

But if it is working, that person has got to be respected and has got to participate in the discussions and the decisions. By the same token, that person and that office, that staff, has got to have stature and be respected in the outside world, because he has got to be able to command the cooperation and the confidence of the external scientific and technical community, because it is through him—I think his main role is to be a match between the political process and the whole, big scientific community on the outside—because he cannot be an expert in everything, but what he can do if he does have this kind of weight is assemble for the President and, really, the whole staff all the best expertise there is in this country as it comes up one at a time.

Well, I think I will leave it at that. I will just say that our problem, I do not think, is how to handle our money better—we obviously have to do that—but it is how to get spirit and drive and imagination back into this enterprise. We need just to gear it up a little bit.

Thank you.

[The prepared statement of Dr. Hornig follows:]

Senate Labor and Human Resources Committee Hearing

"Federal Leadership in Science"

April 6, 1989

Statement by Donald F. Hornig, Chairman

Department of Environmental Science and Physiology

School of Public Health

Harvard University

and

Former Science Adviser to President Lyndon Johnson

Mr. Chairman, members of the Committee. I am very pleased that the Committee has chosen to examine federal leadership in science. There is a wide spread perception that the preeminent place held by the United States in the decades following World War II has been eroding sharply. The loss of the optical and consumer electronics industries to Japan, the adverse balance of trade, even in high technology products, and the evidence that American students do not learn as much science and mathematics as their counterparts in Europe and Asia, have all generated a sense of urgency. It seems plain that we are in danger of losing our preeminence.

What happens in science is only one part of the larger question of how well this country performs but it is a very important part. The federal government plays such a critical role in funding research and development and in stimulating (or inhibiting) industrial advance that the question of what the federal government should do, through what mechanisms it should be done, where leadership and responsibility should be, and how priorities should be set deserve a hard look.

My experience with federal leadership in broad terms began in 1958 when I became a member of the Space Science Board of the National Academy of Sciences. Subsequently I served on the President's Science Advisory Committee (PSAC) under Presidents Eisenhower, Kennedy and Johnson. In 1963 President Kennedy named me his Special Assistant for Science and Technology just two weeks before his assassination. Subsequently,

President Johnson named me to that post as well as Director of the Office of Science and Technology, Chairman of the Federal Council on Science and Technology and Chairman of PSAC. I mention this variety of posts now to point out how much responsibility was vested in that office in the years prior to 1973 when the function was moved out of the White House and in large part abandoned.

Great credit belongs to Senator Kennedy who took a leading part in reexamining the need for scientific and technological leadership in the Executive Office, an effort which culminated in the passage of Public Law 94-282 establishing the Office of Science and Technology Policy in 1976. In the subsequent 13 years the world situation has changed greatly and we have had experience with the operation of OSTP under its new charter. It does not seem to many to have fulfilled the role which was envisioned in 1976. I do not know whether the problems lie in the way the President has used the office or in the structure and charter of the Office. In any case the time is ripe for a reassessment of how federal leadership should be exercised.

I should caution you immediately that the questions involved in examining federal leadership in science are much broader than the structure and composition of the office of the President's Science Adviser. For example, biomedical research and training, involving a federal expenditure of about \$8 billion, is carried on through the National Institutes of Health which are under the oversight of their Director, the Surgeon General and the Assistant Secretary for Health. It is a broadly

integrated operation which includes research, training at the graduate student and post-doctoral levels, faculty development, the provision of modern facilities and instrumentation and so on. The Institutes have always had their own communications channels to the White House and the Congress. OSTP or its predecessors have played only a small part. In the area of health research the National Institutes of Health approximate the much debated Department of Science. In my view this works well because relatively few matters overlap the interests of other agencies and it provides the kind of leadership we seek more generally.

Two thirds of the federal R & D budget (about \$42 billion) is spent by DOD, with little involvement by OSTP. To the extent that technical issues of military security are conceived of narrowly in DOD terms this is satisfactory. There is a high level of technical competence in the military establishment and it is guided through the Director of Defense Research and Engineering and a centralized R & D management. What this arrangement lacks is competence outside of DOD which can bring other considerations to bear, for example, arms control or the impact of defense spending on universities or industrial competitiveness.

There has been a long standing debate over the effect of defense spending, two thirds of all federal R & D, on the civilian economy. It is often argued, on the one hand, that this spending contributes not only to national security but to US commercial competitiveness. On the other hand, critics see it as a prime cause of the loss of competitiveness. What is plain is that the interaction is strong. Especially in

electronics the primary innovations often come from civilian sources; in others such as aircraft military developments have contributed to the strength of our aircraft industry. What this committee might ask is where such questions can be considered in an objective way, free of self interest.

A similar case is presented by NASA where research related to space is focussed. Once objectives are set this is fine but questions concerning the significance and/or value of projects such as the space station need a broader scientific and technical input which is not potentially colored by the enormous stakes involved.

Without belaboring the point, the environment is the responsibility of EPA but much research related to the environment is carried on in NIEHS, NSF and the Department of Agriculture and the Interior. All of it interacts broadly with many areas of scientific development and has an impact on the structure and prosperity of industry. Finally, agricultural research is supported by the Department of Agriculture, but it is being profoundly affected by bio technology which is being developed elsewhere.

This division of labor among agencies is frequently criticized because it is fragmented. However, I think it is not only appropriate but desirable that each of the federal departments and agencies be responsible for maintaining a scientific and technological base which enables it to carry out its responsibilities to the American people. An important question

of science policy and federal leadership is how to ensure that the research base of the departments and agencies is adequate and that high quality people administer and carry out the programs. It is also important that there be good communication channels between the R & D organizations and the top management. Cabinet officers, agency directors and so on need scientific advice and the means by which it is provided needs examination.

In considering federal leadership the committee cannot ignore the fact that industry funds about half of the R & D in this country and that much of the federally funded R & D is carried out in industrial laboratories. Industrial research is naturally oriented toward areas in which the company sells products or hopes to sell products. Only the largest organizations can expect to reap the benefits of general exploratory research. Nonetheless, if they are to innovate and develop new technologies they have to have very well trained people, people who know how to work at the frontiers of their field, and for this they depend on university programs funded by the federal government.

Although important elements of national science policy must be concerned with how to improve the quality of all of these subsidiary research and development efforts and how to insure that they are consonant with broader national policies, I shall not pursue such concerns further today. Rather, there are important aspects of national policy which aren't taken care of by this piecemeal approach and some of them are critical to our health, prosperity and security. Some major ones are: 1) the supply of adequately trained personnel at all levels 2) the conduct

of basic research and the institutions to carry it on 3) the provision of means through which scientific and technological programs affect and are affected by political decisions and political choices.

As for human resources, NIH has taken the responsibility for stimulating the production of high quality biomedical scientists. In other areas the situation is more confused. NSF has dealt with the problem to some extent but it lacks a clean mandate. No one has a responsibility to insure that every one in our enormous school system learns enough science and mathematics so that there will be an adequate number of entrants to technical institutes, colleges and universities. Nor does anyone have the authority or funds to secure a scientific and technical education for every child that will equip him or her to participate as a citizen in a democratic society whose future depends on choices which involve scientific and technological common sense.

This is a big question which I believe should be taken on by the National Science Foundation. It won't be solved by having the right Science Advisor and it is too big to be dealt with by an OSTP. However, a Science Adviser can help to focus attention on these questions and bring them into the councils of the Administration at the highest level.

The basic research program in the US is strong. Our position in the world is preeminent, at least as measured by Nobel prizes. But it is not certain that we are maintaining that position. There are still major questions if we want a vigorous, vital effort. Many different agencies participate in funding basic research. But since scientific disciplines

do not match up with the agency missions the activities of each affect the other. My proposal is that the charge of NSF be expanded so that it has overall responsibility for coordinating the agencies efforts and ensuring a healthy total effort.

Until 1962 science policy was assigned by law to the National Science Foundation and the National Science Board. It didn't work because at that time NSF was too weak in dealing with much stronger science bureaucracies elsewhere. Now the situation has changed. The NSF budget has grown by twenty times and it has moved in the direction of developing national science strategy. Its current Director is an industrial scientist who has moved to revamp the NSF role in engineering research and education and to stimulate university-industry collaboration. I think NSF is now in a position to take on a much larger responsibility to develop a national strategy for science and technology.

The third general area, that of relating science and technology to the political process cannot be dealt with by any of the agencies. Decisions must be made on such questions as SDI, acid rain or the SCSC. They must be weighed, not only individually but since monetary and manpower resources are finite, in the context of all the other plans and commitments. Naturally both the Congress and the President get strong inputs from DOD, EPA and the high energy physics community. The trouble is that their advice is always suspect because they have such an interest in the outcome. Hence there must be a counterbalancing source of advice and judgement. This, of course, is the role of OSTP and the Science Adviser.

Most of these considerations were taken into account in PL 94-382. In fact, so many things were identified as desirable in OSTP that it was assigned more tasks than it could possibly carry out. There is no time today to go into that in detail so I will finish with a few remarks. First, the office must concentrate on translating the goals of the Administration into Science Policy and conducting such studies as are needed to do so. Second, it must make all of the resources of the national scientific and technical community available to the President and his other advisers.

To do these things we need a strong organization with deep roots inside and out of the government. However the details work out, OSTP must participate in determining budgets and management structures. The Director must have respect within the White House and Executive Office and participate in discussions at the highest level. This naturally implies that the individual comes with such stature in the scientific and technological community that he or she can command such respect.

During my term the special Assistant reported directly to the President, not through intermediate staff members. He saw the President face to face when he had important matters to bring to his attention. He sat in on many cabinet meetings and on such Security Council meetings as involved his special judgements and expertise. He lunched regularly with the Secretary of Defense and the Director of Defense Research and Engineering. He and his staff worked closely with the then BOB on budgetary issues involving science. What may be critical is that he

participated in the final budget decisions by the President and was in a position to disagree with BOB or Cabinet officers and expect his point of view to be heard.

Times have changed and what happened 20 or 25 years ago may or may not be germane now. Still, if the office is to fulfill the role we envision it must occupy that kind of position.

This brings me to the other key point. The Science Adviser can be expected to be a person of sound judgement, both scientifically and politically, but he cannot be an expert in all relevant areas. Therefore, he must also be of such stature that he can command the confidence and cooperation of large elements of the scientific and technological community. His office should be the contact point for the Executive Office with the technical parts of the departments and agencies and with the vast external scientific community. To that end he must have some mechanism to provide the outreach of the old PSAC and a staff which is big enough to maintain those contacts and to organize the studies which are the bases for his advice.

In sum the national scientific and technological enterprise is a complex organism in which to some degree all the parts depend on each other. If the federal government is to exert leadership it needs mechanisms by which the whole can focus on national goals and which is guided by a well conceived strategic plan.

The CHAIRMAN. Let me just ask you this question before turning to Dr. Branscomb. How concerned are you that that position is not filled now? First of all, you talked about the type of person who should be in there, but are you concerned—and how concerned—that we have not filled that position?

Dr. HORNIG. I am very concerned. We ought to be off and running. In the new Administration, we should be worrying about just the things we are worrying about here this morning. There is a budget coming up that is going to need some advice.

The CHAIRMAN. Well, Dr. Press talks about the fact that you have some 60-odd billion dollars scattered throughout the various agencies for expenditures.

Dr. HORNIG. But 40 of that is DoD.

The CHAIRMAN. Well, doesn't the Science Adviser have some influence on that as well?

Dr. HORNIG. Yes.

The CHAIRMAN. All right. So 40 there, and 20 on the other side—but that position has not been filled. We heard Dr. Press talk about at least 100 other positions within the Government which have important responsibilities in fashioning and shaping both an Administration's budget and priorities in the scientific area. I do not know offhand how many of those are filled, but—

Dr. HORNIG. Not many.

The CHAIRMAN. Not many. Well, given the general statements, comments and concerns that were expressed even in the last Congress about where we are competitively vis-a-vis internationally, economically, as well as even militarily, what does this mean when we do not have those positions filled?

Dr. HORNIG. Well, I guess it means we are taking a pretty casual attitude toward what I consider a very serious problem.

The CHAIRMAN. Can we afford to?

Dr. HORNIG. Of course not.

The CHAIRMAN. Dr. Branscomb?

Dr. BRANSCOMB. Thank you very much, Mr. Chairman.

The word "crisis" is overused in this town, but I would like to use it. I think we do face one. But there are two kinds of crises. There are the kind that happen all at once, like Sputnik or a dramatic event like a Exxon oil spill, and there is the kind of crisis that does not happen all at once, and that is the one we are suffering from.

I would like to just read a sentence from a report by Professor Robert Gilpin to the Joint Economic Committee of the Congress. He wrote: "Technological innovation in the civilian industrial sector of our economy is at a critical point. Partially due to policies pursued, or rather, not pursued, by Government and industry, and partly due to developments beyond our control, America's once unchallenged scientific and technological superiority have deteriorated. The implications of this reversal are of immense importance for both our domestic welfare and our international position."

Now, that is not an unusual statement to hear in Washington these days, but that was written in July 1975, 14 years ago. And in my testimony, I can give you a very interesting quote from Maurice Stans in 1971, when he went on to say that in fact, if we are going to maintain our civilian R and D advantages, we have to

accept the idea that it is a proper sphere for governmental action. So I do not think it is a partisan question whether or not Government has a responsibility to do something about the technological roots of our national well-being.

Well, we have had this big argument on whether or not we have a macroeconomic problem or whether we have a skill/knowledge/technology problem. In point of fact, we have three problems. First, our national self-indulgence has burdened us with foreign debt, accumulated deferred investments and excessive costs of capital. We are selling off our capital now as a way of trying to cover that debt.

But secondly, we have failed for over a decade to face up to the policies and investments that are needed to revitalize public education, industrial innovation and economic productivity—the questions addressed in Mr. Gilpin's Congressional report.

And finally, while we are not facing up to our responsibilities, our competitors are moving faster than we are on both fronts, both through sound macroeconomic policy and in education, research and technology.

So we ought to quit arguing which is the problem and recognize that neither set of solutions, neither good economic and fiscal policy nor investments in science and education, will solve our problem alone. We are going to have to do them both.

Now, I would like to start by addressing what I think is the crucial question of the linkage between Government science and private science.

The CHAIRMAN. Just before you leave that, why is the overall economic condition so much a part of this whole problem?

Dr. BRANSCOMB. Well, it is a part of it, first of all, because the Congress cannot close the budget gap, and finds itself unable to even contemplate serious additional investments at a time when, clearly, we need them.

We look at this chart, and I would say that our President ought to tell the American people that it ought to be our goal, perhaps by the end of his Administration, to try to get to 3 percent on that chart. The Japanese will be at 3 percent in a few years. And most of that growth ought to be in the private sector, not in the Government budget. But it will take Government policies and programs to incent the private sector to get there.

Secondly, the big coupling is through, I think, the cost of capital, which itself makes companies have to get a higher return on their equity, return on their capital, that requires that they do this much talked about quarterly profit management—they have to get a quicker return because they cannot tolerate the same level of technical risk that the Japanese can tolerate with much lower costs of money. Many of the economists, in fact, believe it is that cost of money that is the essential linkage.

But the two problems are indeed closely coupled. They are also coupled by the fact that foreign purchases of our small, high-tech companies have been growing apace, and that is a consequence of the low dollar, which is a natural consequence of our lagging productivity.

So the poor technology-performance also exacerbates the economic problem, because when the dollar reaches its equilibrium with the yen, we now find that it is very cheap for foreigners—in fact,

more Germans and British than Japanese—to come over here and buy our companies. It is going to be a long road back to recovery.

The CHAIRMAN. I do not want to over-emphasize this point, but I have heard it said there is all the money available in the world in terms of venture capital for small companies here in the United States, that there is just all kinds—maybe it is foreign; I do not know how you allocate it between American and overseas, but it is supposed to be readily available, I understand. Maybe I am wrong.

Dr. BRANSCOMB. It is my impression, Senator, that that was the case and is no longer. I am a Director of the Massachusetts Centers of Excellence Corporation, and we stay fairly closely in touch with that issue in Massachusetts, and my impression is now there is venture capital money, but the small entrepreneur has to give away a lot of his equity and control of his firm to get it. So it has become much more conservative.

Now, I wanted to touch on a few issues that do not get as much public discussion as they should, one which I believe is at the heart of the coupling between Federal science and private innovation. It has to do with industry partnerships for strategic research.

We do not even have a good language to talk about what kind of R and D is appropriate for the Federal Government to do and what kind is inappropriate to do in order to encourage the economy. We all understand what pure basic science is, when we are talking about astronomy or fundamental biochemistry or pure mathematics. But when you ask a Japanese what research are you doing, and he says I am doing basic research, and then you say, well, give me an example; he says, well, I am working on the characterization of these new composite materials, or I am inventing a new kind of instrumentation, or I am concerned with how to build computer models of this engineering process.

Now, we do not call that basic research over here, and if you want to do this kind of useful, pre-proprietary, noncommercial, but very useful kind of research, you cannot get that in competition with a pure science, peer-reviewed agency like NSF—or, at least, it is difficult, except in engineering, and they have a very small engineering budget. Traditionally, the mission-oriented agencies of our Government have funded that kind of useful science. And as Don pointed out, over the years, they have gradually shed more and more of their basic science investment and left it to NIH and NSF, which shifts the center of gravity of our research excessively in the pure direction, in my opinion.

The Defense Department, which is the biggest single investor in research in this country, is the worst performer. Since 1980, Defense RDT&E, the R and D in the Defense Department, has essentially doubled, gone up by a factor of 1.94 in real dollars, not in current dollars—even more in current dollars.

We have trebled the part of the Defense budget that goes into operational systems. We have multiplied by 2.5 the actual development of weapons. But our basic research, 6.1 money, increased 16 percent over the last seven years in real terms, and our exploratory development, the 6.2 category, which is what industry really is interested in, has actually shrunk in real terms in seven years.

So one of the things we have to do is to find a way to get a much broader base of strategic research going on in a partnership be-

tween the Government and the universities and the corporations, and I think——

The CHAIRMAN. On that point, though, to what extent is that a result of the fact that, with the progress that has been made in various weapon systems, that there is less spinoff in terms of the civilian industrial sector? I hear that that is a point. I do not know whether it is accurate or not.

Dr. BRANSCOMB. Let me say that is a subject on which I would love to give you additional information, because I have five faculty members and a major research project just on this relationship between defense research and civil research. But the quick answer is that the Defense Department has cut back on that very part of their research program which has big spinoff, mainly the exploratory development and basic science, and they have diverted the funds to the part that does not.

The second factor, which is important for all of us to remember, is that while the defense budget is big, and in fact, about 40 percent of all national R and D is defense-related, public and private money. Nevertheless, the thing that has really happened since 1960 is that high-tech industry has come on the scene, and the private sector expenditures in R and D, in private industry, have increased by a factor of 2.5 times the growth of defense industry R and D in this country. So in the United States since 1960, we have seen this very large private industry appear. Of course, it also appeared around the world, and it appeared in Germany and Japan, where there is no defense industry. So in the world pool of technology capability, if you want to think of it that way, the U.S. defense contribution is much smaller than it was in 1960.

So even if the spinoff processes were working as well as they used to—and they do not, they do not—even if they were, defense has a smaller contribution to make.

In my written testimony, I give six specific suggestions, not for turning our Defense Department into the industrial policy agency of the United States—I think that would be a serious mistake—but I think the Defense Department ought to give us more military security for less money, and I think there are at least six ways to do that which, by the way, would also have the effect of giving a much bigger positive contribution to commercial industry. Partly, it is a big political problem, because the country has lost confidence both in the Defense Department and in the defense industry that it does business with. But I think that is a very important issue.

The CHAIRMAN. Are you talking just about weapon systems, the way they purchase different systems, the types of systems that we have, or——

Dr. BRANSCOMB. Yes. Let me give you two examples. One is that, as Dr. Hornig pointed out, there are many areas of technology now in which the private sector has moved so fast that the technology flows the other way; and yet the Defense Department is not positioned to avail itself of the competence of private industry, and that is true in two respects. One is they go out and develop unique equipments when, in fact, commercial companies make commercial equipment they could perfectly well use if it were just hardened and available for defense and if the defense mill specs did not prevent them from buying it.

You have a splendid example in your State. Last year, Digital Equipment came out with a new line of VAX computers, improved architecture and new hardware. The same day they announced their commercial line, Raytheon Corporation in Boston announced a product called the Mill VAX. And DEAK had given Raytheon, I assume several years in advance, all the detailed plans for this new computer. Raytheon built it in their own hardware to military hardness—in fact, configured a little differently, so it would be appropriate for military use—they announced it the same day, and it is only 30 percent more expensive than the commercial version, and the military version is hardened, so it ought to cost more.

Now, that is a real bargain if the Defense Department buys it, for the simple reason that you can use all the commercial software; you've got these rafts of people in the Digital Equipment Company to support it, as well as in Raytheon.

So that is what we call civilian off-the-shelf technology, and if the Defense Department worked at using it, we could leverage our commercial industry.

The CHAIRMAN. Have you got examples that go the other way?

Dr. BRANSCOMB. Yes, there are examples that go the other way.

The CHAIRMAN. I was thinking of examples of where they are perfectly available, there off-the-shelf, and we are still purchasing them at a significant increase in the amount of resources to buy that type of equipment or to develop that type of equipment. Are there examples like that?

Dr. BRANSCOMB. Well, the military, of course, do use an enormous amount of ordinary commercial products. I am thinking now of equipment—because they buy cloth, they buy uniforms, they buy aviation lubricants, et cetera—which is the same for civilians and for the military. The biggest change, I think, is that increasingly, they are finding it necessary to depend upon private sources at the component level in electronics, for example, and that is causing concerns, because they are unclear how much of that is U.S.-manufactured and how much is foreign-sourced. So the dependency issue is a problem.

I wanted to give you one other example because it reads on a point I wanted to make in another context. In 1986, the Congress changed the procurement laws for the Defense Department in order to try to get more competition into the process, being concerned about some of the scandals we hear. And one of the changes in that 1986 Act requires that in many situations Defense, after they have awarded an R and D contract, and the R and D has been successfully performed by one or more companies, they then go for entire new competition for the production.

When you do that, you separate the R and D from the production, it is now unreasonable to expect those that do the R and D to think a lot about how this thing is going to be manufactured. After all, the company doing the R and D does not know it is going to get the production contract. And that forces a linear approach, a sequential approach, to innovation, starting with research and ending up with production. That is not the way commercial industry competes today. You have to start out at the very beginning, thinking about how you are going to manufacture, and you need scientific levels of skill in the manufacturing environment.

The Defense Department contributes very little of that understanding about manufacturing—they are trying to now, but they structure their own business so as not to be driving private industry strongly in the direction of low-cost, high-volume manufacturing. And one of the things this country needs to worry about—and I would like to see the Commerce Department get involved in it through the new Technology Administration—is to help our engineering schools change their curriculums to help young engineers prepare themselves for careers in production. We have been doing that for years in chemical engineering, and by the way, our chemical industry is very competitive with the Japanese and the Germans—and it gets very little help from the Government, I must add. But we do not do that in the other areas of engineering, and manufacturing is very much a part of our competitive problem.

The CHAIRMAN. Is that true in the business schools, too, in terms of finance rather than in terms of production?

Dr. BRANSCOMB. Absolutely.

The CHAIRMAN. And how do you—

Dr. BRANSCOMB. Some of the business schools have seen the light. Harvard Business School had a very famous man named Abernathy, who died, but his colleague Hayes still teaches, and the school takes production very seriously, and they talk a lot about it, but the students do not like to take the classes. My students go over there and take those courses, and they tell me there are empty chairs in the classrooms on production, but not in the classrooms on finance.

By the way, we can take some solace in news I got from Japan two weeks ago. The policy people made a study over the last five years of what happens to the top quartile in ability of science and engineering graduates from the two top universities in Japan, namely, Tokyo and Kyoto. Every year, an increasing fraction of those students have gone into investment banking, so they have caught the American disease.

The CHAIRMAN. You mentioned those six broad categories early in the testimony. I could not find that. Could you just run through them quickly?

Dr. BRANSCOMB. Yes, those relating to the Defense Department. One is restoring the budget in the 6.1 and 6.2 categories, the generic research.

Second is encouraging the commercialization of defense-relevant IR&D. The independent research and development program is a very complicated and confusing one for the Congress. But it is a fascinating thing that in NASA, if you are a company, and you are negotiating for your IR&D allowance, you have to show that you are going to make an effort to get it commercialized and not just use it for NASA. In the Defense Department, if you do that, they put you in jail. You must be very careful not to be caught commercializing what you do.

I noticed in the paper the other day Litton Industries is in trouble because of the way they cost-allocated their computer services between defense and non-defense.

So the concern we have about improper allocation of cost to the military is causing us to make it very tough for companies to share.

Restructuring the requirements process is an important issue. In the military, we tend to spend a couple of years studying what the service needs in the way of weapon systems, and once that study is complete—and there is a book this thick that describes the requirements—you then put it out to bid.

If a company looks at that bid and says my goodness, that is a hard thing to make—but if they would be willing to back off 10 percent on the function, I could do it for half the price. If you come forward with that, they say, no, you cannot do that; these are the requirements. If you back off the function 10 percent, people will die in the war.

So it is very difficult—they are experimenting now with cost-defined, cost-permissive contracts, where the Defense Department goes out and says we've got this much money for this kind of weapons system; what is the best weapon you can give me for that money? That is a much more commercial-like approach and, I think, will save the country a lot of money.

I did mention the other two things—the review of mill specs, which needs to be compared with commercial/industrial standards, because in many cases they are arbitrarily different for no good reason, and that prevents the military from using the standard commercial components. And the final point was the civil off-the-shelf technology.

Thank you, Mr. Chairman.

[The prepared statement of Dr. Branscomb follows:]

Testimony
Senate Labor Committee
April 6 1989

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Mr. Chairman, I am pleased to respond to your request for my views on the state of American science and technology and what should be done to strengthen it. At issue is the vitality of our industry, the strength of our security, the public health and the quality of our environment. But the most important issue is education. Will we equip the public, young and old, to use the enormous reservoirs of intelligence and energy that Americans have always summoned up in times of crisis?

Crisis is not too strong a word; but I do not use it in the sense of a sudden calamity. The problems America faces have not come on us suddenly.

A Problem Long Misunderstood and Neglected

Let me quote from a report by Professor Robert Gilpin prepared for the Joint Economic Committee of the Congress on the subject Technology, Economic Growth, and International Competitiveness:

"...technological innovation in the civilian industrial sector of our economy is at a critical point. Partially due to policies pursued (or rather, not pursued) by government and industry, and partially due to developments beyond our control, America's once unchallenged scientific and technological superiority has deteriorated. The implications of this reversal are of immense importance for both our domestic welfare and our international position."

This was not written last month or last year; it was written in July 1975 - almost 14 years ago. His was not the only voice raising concerns. In fact, throughout the 1960's, when I was at the National Bureau of Standards a Department of Commerce economist named Michael Boretsky was a lonely but persistent voice, warning that only in the high technology sector was the U.S. enjoying a positive balance of manufacturing trade - and that this lead was eroding.

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He called for conscious federal efforts to reverse this dangerous trend. Since then we have heard endless debates about the limitations of government action, the dangers of industrial policy, the need for patience to let the hidden hand of economic competition solve our problems.

But thoughtful leaders of both parties have given testimony to the necessity of concerted public and private action over many years. Let share with you a quote from congressional testimony that again might surprise you as to date and source:

"The magnitude of the problem is such that we cannot rely upon normal forces to maintain our advantage in technology. We are at the forefront in many technological areas. The costs of breaking new ground in some of these areas are high - higher than private companies or perhaps even private consortia are able to justify because the risks are so great.

We have recognized this fact in space, defense, and atomic energy areas. Other trading nations have recognized it in the area of civilian R&D and have taken steps to assist technological development. If we are to maintain our advantages in this area we must first of all accept the idea that it has become a proper sphere of governmental action."

[Emphasis mine.] This is the voice of Secretary of Commerce Maurice Stans, addressing the House Science and Astronautics Committee in July 27 1971.

We forget that back in 1960 military technology dominated private technology (6.0 B to 4.52 B). In that year 80 % of federal R&D investments were from Defense. If you include Atomic Energy and Space it was 93% in 1963.

Since that time the big change is the world-wide rise of private, high-tech commercial industry. From 1960 to 1987 civil industry funded R&D grew 2.5 times as fast as did military R&D. More important, it grew fast in Japan and Germany, where there was little defense research. Thus by the 1970's there appeared in the free industrialized nations an enormous volume of commercial technological capability. Our policy assumed that this meant the role for government was to continue the very large, occasionally heroic projects that industry could not afford, and in commercial technology take only a passive role; other governments did not make

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that assumption.

By the early 1970's it was beginning to be clear that America's extraordinary achievement in the Apollo moon landing did not assure us of a healthy civil economy. The task of safely transporting 3 men 250,000 miles to the moon was not the same as transporting 250,000 people three miles to work. The moon trip cost \$1000 a passenger mile; the commuter trip had to be done for 17 cents.

Macroeconomics or Research and Education?

In the years since, we have had a long debate about the source of the trend toward relative decline in America's economic position. Are these economic trends rooted in other countries' more rapid progress in technology, education and management? Or will these macroeconomic trends solve themselves in good time, given prudent fiscal policy, the stimulus of open markets and a restructuring of the American economy?

The truth is that the U.S. is burdened in three ways:

- (1) our national self-indulgence has burdened us with foreign debt, accumulated deferred investments and excessive costs of capital.
- (2) We have failed for over a decade to face up to the policies and investments needed to revitalize public education, industrial innovation and economic productivity.
- (3) Our competitors are moving faster than we on both fronts: economic policy and education, research and technology.

We should not try to resolve the argument over which is more important: macroeconomics or skill and knowledge? Balancing the budget or providing a competitive education? Increasing the savings rate or expanding university-industry research partnerships? Lowering the cost of capital or investing in the more productive industrial processes that capital will have to pay for? We will have to do them all, and having delayed a decade or two after we had all the evidence necessary to motivate action, we will have to move swiftly on a bi-partisan basis.

Too Little Investment, Too Low Priority for Technology Policy

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as a percentage
of GNP

The fact is that in 1960 the U.S. spent a higher fraction of GNP on R&D than we do today. With our larger economy and large military commitment we do outspend the Japanese in R&D by 2.7 times. But, the non-military R&D investment of the U.S. is only 2/3 as large an investment as that of Japan. And of that residual a larger fraction of Japanese R&D is funded by and performed in industry.

What is more, the Japanese companies have a voracious appetite for new technology - including still speculative ideas from the scientists' bench. I have heard too many examples of American scientists working in government or university laboratories who tried with little success to interest American companies in a new idea, all the while holding off Japanese firms eager to provide funds to accelerate the work.

This voracious appetite for technology extends to their public policy as well. Without debating the wisdom, the motives or the success of their governmental technology strategy and its influence on commercial industry, let me note how much more seriously they seem to take the importance of technology to the national agenda than do we.

In Japan the top science and technology policy body is a council chaired by the Prime Minister, on which sits the Ministers of Finance, Science and Technology, MITI, Education and the academic scientist chairing another body - the Japan Science Council, which looks after basic research. The Science and Technology Agency created one year ago a new National Institute for Science and Technology Policy (NISTEP) with five divisions of experts, lead by internationally known science policy experts.

In the U.S.A. we have yet to see the appointment of a Director of OSTP and provision of adequate staff. We have much more powerful policy analysis capability than does Japan - in key agencies, in the National Research Council, the Congressional agencies like OTA and in the universities. But we do not have in the Executive Office an technology executive who can set the agenda, command attention across the government and outside, and expect to implement what is decided.

This nation has a long agenda of neglected work to set our science and technology policy straight and find the consensus to implement it. I would like to submit for the

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record, if I may, a three page list of possible initiatives that I prepared for this hearing. This morning, I would like to concentrate on only four of the most important:

- (1) The needs of industry for a research partnership with universities and government in strategic areas of science and engineering.
- (2) The critical role of educational renewal - at all levels from preschool to graduate school - if there is to be any hope of a technological turn around.
- (3) The contribution the Department of Defense could make to the civil industrial base.
- (4) The critical need for central leadership and coordination of \$67 Billions of federal R&D in the Executive Office of the President - including setting goals for national S&T investment.

Industry partnership for strategic research

At the center of our confusion over the federal role in technological renewal is the lack of consensus on how to distinguish the types of research investments appropriate for federal funding from those which might simply substitute for private funds, be wasted for lack of market knowledge, or might unfairly interfere with the competitive process.

We all understand - in a general way - what university faculties mean by "basic research" - the quest for knowledge without near-term expectation of practical reward. That definition insures that no one will say this is an inappropriate federal investment - indeed conservatives and liberals alike agree that the federal government is the only practical source of funds to sustain the excellence of this level of science.

But we do not even have an agreed language to describe the kind of research that is of much more direct value to industry, while still appropriate for public investment. I have in mind fundamental investigations into very practical questions - but still of great scientific and engineering importance: the characterization of new materials, research in opto-electronics, micromechanical engineering, new architectures for computers, bioengineering techniques for making useful enzymes, new algorithms for computer aided design and production, better ways to design

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and build computer software, unraveling the mysteries of catalysis, new kinds of scientific instruments or process tools.

These are the kinds of useful science and engineering research that are the daily bread and butter of academic engineering laboratories, and they are of great interest to scientists in universities, government laboratories and industry research laboratories as well. But they are not the very most fashionable areas of science. They will not be as strong candidates as molecular biology, cosmology, or high energy physics when measured for their intrinsic intellectual potential.

We do not even have words that we can all use to describe this kind of science. Europeans would call it "pre-proprietary" or "strategic" research. American agencies sometimes call it "generic" research or "basic technology". The Pentagon calls it "exploratory development". Only the Japanese do not find this a problem. They call it "basic research".

The GAO has pointed out that the R&D taxonomy used by NSF and adopted by all the other civilian agencies has only the categories "basic" research, "applied" research, and "development"; while the Defense Department uses quite a different system. Until categories better related to the purpose of the investment are adopted it will be very difficult to build a rational budget process for making tradeoffs in the federal S&T budget.

The reason this kind of technological knowledge is very valuable is because it can be turned to good use very quickly, and the people trained in this kind of work have skills for which industry has a high demand. This is also the reason it is politically difficult to provide the right kind of funding for it, for it is close enough to industrial interest to arouse questions about its appropriateness.

The result is that funding comes mostly from the so-called mission-oriented agencies of government, and therefore the priorities derive not from what industry needs to advance on a broad competitive front, but from what a government agency is charged with doing. These priorities are, therefore, not open to debate and challenge.

A Civilian DARPA

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The Defense Advanced Research Projects Agency (DARPA) does not get challenged on the economic relevance of their research agenda; they need only satisfy the Secretary of Defense that their work is relevant to DoD's statutory responsibility. If a "civilian" DARPA were created in the Commerce Department, aimed at economic renewal in civil industry, means for adjudicating the many strategic interests of the private sector would have to be invented. And to insure that only the very best projects are selected from this agenda, the strategic priorities would have to be combined with a competitive peer-review evaluation among candidate proposals. The defense mission cloaks the program manager with a degree of independence of judgement that is essential to good research management. This will be harder to achieve in civil agencies, and will need a lot on Congressional understanding.

However, the government has a lot of experience with programs of this type, much of it quite good. The National Bureau of Standards, now called NIST, has conducted cutting edge research of this useful kind for almost 90 years. Amid some controversy from the pure scientists, NSF - with the President's backing - has been seeking congressional support for cooperative research with industry of this kind. It is time for a serious effort to define the policies and build Congressional support for a major expansion of this kind of strategic fundamental research funded in partnership with industry through many agencies of government, including the Department of Commerce.

The trend, unhappily, has been retrograde, especially in Defense. Between 1980 and 1987 the Research Development Evaluation and Test expenditures of the Defense Department have risen by a factor of 1.92 in real terms. That is, R&D purchasing power has almost doubled. But within this budget the funds for operational systems evaluation (6.6) trebled, and manufacturing prototypes (6.3B) increased by a factor 2.46. Yet the increase in basic research (6.1) was only 1.16 and the exploratory development category (6.2) - the one of greatest interest to industry - actually shrank a little.

NIST and the DoC Technology Administration

I view the creation of the Technology Administration in the Department of Commerce, and the extended mission of the National Bureau of Standards into industrial extension under the new name NIST, as singularly promising events. The National Science Foundation has its hands full trying to

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keep American basic research in the physical sciences strong, building up engineering research and meeting the challenge in mathematics and science education. The Commerce Department must step forward to carry its part of the responsibility, only for research strategies in collaboration with industry, but in the expansion and redirection of engineering education as well.

Manufacturing: Downstream engineering skills

The U.S. competitiveness problem is not, at heart, an R&D problem. The central issues are product appeal, cost and quality. These depend on design, process development, manufacturing systems engineering and quality management, all carried out in an innovation system that features very fast iteration to adapt to new news from the market or from science.

The mission is that of the factory, not the laboratory. But the skills are increasingly those Americans find only in the laboratory. We must address two issues at once:

(1) It is industry's job to remake their factories into places where high-technology can flourish, with factory managers who can attract high-skilled engineers and even scientists. This change is underway in many industries, but it requires huge cultural changes that are agonizingly slow to accomplish.

(2) It is engineering education's job to bring to the factory the full power of modern technology: computers, processes, materials and to provide role models for students that will motivate many of the bright ones to take up careers in production.

Where can engineering education hope to get financial help for this major change? Today they get increasing amounts of support from industry, but the process is too scattered, too small and too slow. But at NSF, the tradition is to bring about curriculum change through research funding. And since engineering receives less than a fifth of the research budget (although it is the fastest growth area), the leverage here is quite weak.

I believe a frontal attack on the technical quality of our production base - primarily by voluntary association of industry and engineering education - but encouraged and supported by the federal government is urgently needed.

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It is important to note, by way of justification, that the federal government is in part a cause of this split between industrial production technology and academic engineering education. This follows from the dominance of Defense, Energy and Space support for academic engineering. With rare exceptions, these agencies are not interested in technologies for low cost, mass production. They encourage engineers to find sophisticated technical solutions to problems with little regard to manufacturing or cost.

Math and Science Education

The most serious problem on the education front is, of course, the deterioration of educational achievement in many of the public schools and the failure to make progress in others - especially in math and science.

I will not repeat here the grim statistics of aggregate measures of U.S. student performance on standardized tests, or the critical shortage of science teachers. I only want to emphasize two points:

(1) The problem is sufficiently serious that the debate about whether the federal government has any responsibility must not be a question of constitutional theory, but a practical question of whether the federal agencies have any credibility on this issue and can in fact make a contribution.

(2) Giving the schools more of what they already have - more curriculum, more technology, even more teachers and more money - will not be enough; structural reform, along the lines pursued now by many Governors and recommended by the Carnegie Corporation Task Force on Teaching as a Profession in 1986 is required.

This is not the time to address the entire education reform strategy. I know the chairman is well informed and is solidly behind the reform effort, including his support for the one time matching appropriation to fund the developmental research of the National Board for Professional Teaching Standards at the full \$25 M level.

In Math and Science, the National Science Foundation does have credibility - certainly more than the Department of Education. But NSF is still regarded as addressing K-12 education too much through the medium of unsolicited

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research projects from colleges. I believe the NSF must look on its responsibility in K-12 as of a different nature from its research work in the universities.

NSF must learn the issues, the players and the politics of public education. It should ally itself with the strongest forces for reform. It should work directly with state systems and school districts and with teachers. And it should use its limited funds to leverage the reform efforts of the schools.

Those dependent on NSF for research support in science often note that the NSF education budget is too small in comparison with the \$22 billion DoEd budget or the \$150 B spent by the states to have much effect. I disagree. I have seen so many state reform efforts slowed or sidetracked for want of a small sum of risk money for an educational experiment, or an inducement to bridge institutions or communities, I am sure an activist approach by NSF would bear fruit.

NSF would be even more effective if the congress could work out ways that successful NSF efforts could leverage operational level funding at Dept of Ed. And finally, let me note that the politics of NSF are such that Congress should work with NSF to find ways to grow the education budget without doing so by reprogramming or reallocating budgets requested for research.

Dept. of Defense support for the Industrial Technology Base

It would be a serious mistake, in my view, to expect the Department of Defense to conduct surrogate industrial policy for the country. First, its relations with industry have become even more hostile than those of the civil agencies. Its undoubted capacity for managing high-tech R&D leads it to micromanage, and ill suits the relationship needed in industrial technology. Finally, until defense can get its own acquisition house in order, including a radical improvement in its ability to inject incremental improvements in technology in its systems and deploy them in a timely manner, it is hardly in a position to improve competitively pressed commercial industry.

On the other hand a set of strategies that would enhance the Defense community's ability to defend the nation more economically would also provide positive stimulation to commercial industry. These include:

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- 1) Restore proportionate investment levels in 6.1 and 6.2 research categories to their 1980 levels.
- 2) Adopt NASA's policy of encouraging defense contractors to commercialize technologies developed with their IR&D funds, rather than punishing it.
- 3) Change the military requirements process to encourage bidders to offer modification to system requirements if they would bring large economies.
- 4) Review the full range of MILSPEC standards to seek maximum compatibility with commercial engineering standards.
- 5) Provide significant incentives for the production of "civil off-the-shelf" (COTS) products for use in military systems.
- 6) Remove the 1986 procurement act requirement to separate contract competitions for R&D from production, in order to ensure that manufacturability is a central feature of systems design.

OSTP and Central Coordination

I will not discuss here the need for a budget process that permits issues in national science and technology to be addressed by the agencies when the budget is assembled, and the appropriate trade-offs to be made. Please note, though, that the balkanization of appropriations subcommittees in the House and Senate does limit to some degree the value that such tradeoffs can have.

I would rather focus on three points about the importance of a strong, industrially experienced science and technology Assistant to the President.

- (1) Without a strong office in the White House, we have no Minister of Science, no senior technical official who can speak for the entire government. The need is well illustrated by the FSX negotiation, which is a serious embarrassment to our Japan relations.
- (2) Given the almost equal split between federal and private investment in R&D, and the 40 - 60 split between defense and non-defense R&D, the executive office of the president must resolve the issues of technology policy that arise in

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economic and trade policy, and must seek cooperation and make trade-offs between defense and civil agencies in programs to strengthen the industrial technology base.

(3) The President should set a strategic goal for building up both private and public investments in science and technology. A reasonable goal would be to bring U.S. national investments in R&D, not counting military development and operational system DT&E, to 3 % of GNP. The tools for this are very broad, and include the R&D tax credit. Most of the growth should be in the private sector, through improving industry's environment for risk taking and reducing its cost.

Conclusion

It is bad enough that our private industry has become non-competitive in one area after another - consumer electronics, numerically controlled machine tools, large parts of microelectronics, fine ceramics, low end office machines, many areas of manufacturing equipment. Our public sector is becoming non-competitive too. We have allowed the \$ 300 B education industry to fall into disrepair even though it must provide the basis for the industries in which we can hope to have a comparative advantage in the information age.

We surely do not resent the progress made by others. But when I go to Japan I hear good friends of America unable to understand why the United States, which they so admired and worked so hard to emulate, seems adrift, unable to foster, protect and exploit the talent for science, technology and entrepreneurship for which Americans are so justifiably famous. We Americans save too little, consume too much, and are living on borrowed foreign money and the sale of our capital assets: our land and our industry.

Our competitors are losing their respect for us, and as an American patriot I find that very hard to take.

We need the vision and sense of purpose that Harry Truman expressed over 40 years ago, when he announced his intention to double the total public and private investment in science, to establish the National Science Foundation, to expand scholarships and research facilities in the universities and better finance and coordinate the work of federal research agencies:

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"If we are to maintain the leadership in science that is essential to national strength," he said, "we must vigorously press ahead in research. There is one simple axiom on which this thought is based. The secrets of nature are not our monopoly. Any nation that is willing and able to make the effort can learn the secrets that we have learned."

"Now and in the years ahead," he went on to say, "we need more than anything else the honest and uncompromising common-sense of science. Science means a method of thought. That method is characterized by open-mindedness, honest, perseverance, and above all, by an unflinching passion for knowledge and truth. When more of the peoples of the world have learned the ways of thought of the scientist, we shall have better reason to expect lasting peace and a fuller life for all."

Suggested Initiatives in Science and Technology Policy

Lewis M. Branscomb, Director
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April 4, 1989

Human Resource Issues

* Federal role in K-12 Education Reform: the federal government must put its strength behind the states seriously engaged in restructuring their schools. Federal investments in upgrading Math Science and Technology education should be done so as to leverage those states making real progress.

- Initiate a National Commission on the financing of public education, as recommended by NSB Commission on Math., Science and Technology Education.

- Provide \$ 25 M Federal matching for National Board for Professional Teaching Standards.

* The Demographic Challenge: encouraging qualified Americans, especially women and minorities to study S&E: filling the pipeline, fixing the leaks. Specific encouragement to enter teaching through baccalaureate in science followed by a masters in teaching.

* Staffing our college faculties which face heavy turnover in next few years when doctorates are declining: sustaining the doctorate programs; restoring tax exemption for fellowships; funding increased fraction of research costs through fellowships for citizens with proportionately less reliance on research assistantships.

* Major rejuvenation of the quality of U.S. manufacturing: Engineering education for careers in production; partnerships with industry in curriculum development and plant floor experience. Special emphasis on mid-sized industrial specialty companies.

* Life-long technical re-education: incentives for industry, such as the French retraining tax (so mobility does not penalize companies with heavy education commitments).

* Educational technology: use the federal agencies as a show-case and safe money in the process. Fund the national Research and Education Network.

Federal R&D Budget Process

* Strong encouragement to the Administration to establish a strong management capability in OSTP capable of getting a balanced technology strategy in place for the federal government.

* Strategic support for growing national (not just federal) non-military

R&D to 2.8% of GNP through modification and extension of the R&D tax credit, growth of academic science and engineering, and new investments in strategic, generic research providing a base for industrial technology development in critical areas.

* Support for a 5 year authorization and 2 year appropriation cycle for S&T.

* Congress to match the President's willness to present a strategic federal R&D budget with the Joint Budget Committee's willness to make the corresponding allocations to appropriations subcommittees.

* New taxonomy of science and technology activities to support rational budget evaluation, as recommended by GAO.

* Rational and public process for assessing the technical merits of plans for Big Science and Engineering projects in pursuit of goals for which Congress determines the indirect public values.

Strengthening the Civil Industrial Base; Federal Agency Roles in Economic Renewal

* Defining the responsibilities of Department of Defense for the national technology base on which defense depends and to which it should contribute;

- restoring growth in 6.1 and 6.2;
- encouraging commercialization of defense-relevant IR&D; - encouraging technology development in second tier contractors;
- restructuring the requirements process;
- review of MILSPECs vs. commercial industrial standards - removing barriers between RDT&E and production contracts;
- inceniting Civil Off the Shelf (COTS) product offerings.

* Building strong capability with realistic funding in the Technology Administration of the Department of Commerce;

- Encouraging technology diffusion through industrial extension driven by states with support from NIST. (Initiated in the Omnibus Trade Act of 1988).
- Encouraging the technology administration to share with NSF the human resource development for down stream engineering jobs in industry.
- Support for state programs aimed at new job and new firm creation through research - industry partnerships.
- Development of technology promotion strategies coupled to trade policies.

* National Science Foundation to receive the rapid growth necessary to fulfill four goals, where today only one is funded, and that inadequately:

- Insure the knowledge base and research capacity in our universities necessary for a fully competitive economy and the acheivement of social, environmental and national security goals;
- Insure an adequate education in math and science for all citizens and reverse the decline in the number of US citizens prepared for competitive careers in science and engineering;

- Upgrade the training of engineers and the practise of engineering in design and production as well as in research, to take full advantage of the latest technology, in collaboration with industry and the Technology Administration in Commerce;

- Support the formation of bridging institutions between universities and industry and encourage the development of science and engineering information services to insure the rapid and productive diffusion of new knowlegde to those who can use it for productive purposes.

* National Institutes of Health should be given an explicit charge to carry out its work in such a way as to enhance the development of a competitively successful U.S. biotechnology industry - both because of the contribution that industry will make to public health and because of the economic value of the industry to the nation.

* OSTP should be missioned to establish a federal information policy for science and technology designed to maximize R&D productivity in the U.S., to protect U.S. intellectual assets, to promote international cooperation where that is in the U.S. and world interest.

* National Laboratories are a seriously underutilized resource, and some part of their capabilities should be immediately deployable by the President (through OSTP) to new work each year, giving the federal government a quick response capability to new scientific advances, following a system successfully used in the French government.

The CHAIRMAN. Let me ask first of all, Dr. Hornig, in terms of science education, as I gathered from your earlier testimony, that ought to be in the NSF? How do you view the Department of Education, or what role should they have?

Dr. HORNIG. Well, the Department of Education has a complicated history. For a long time before it was a department, it was essentially a statistical bureau, and it never has really taken a leadership role in education; it has never really understood anything, as far as I can tell, about what scientific and technical education was. So that my opinion is that NSF has roots in scientific education, and it has practiced it over the years, and it is the obvious agency to move in on that problem.

The CHAIRMAN. Do you have any comments about the current budget allocations in the NSF in terms of the educational function?

Dr. HORNIG. Well, I wish it would do more in education, but I don't think it should be done at the expense of its research programs. That is the spot that they keep on being put into. People say you ought to do more education, and we will arbitrarily tell you to double the amount, but we don't increase your budget so that it comes from something else, and then the whole scientific world revolts.

The CHAIRMAN. Dr. Branscomb, let's just continue on the question of scientists, engineers, the training at the graduate level. Many have expressed concerns that we are not doing enough. First of all, do you agree with that; and then secondly, do you have suggestions as to how you go about encouraging more students to get into those careers?

Dr. BRANSCOMB. I think we do indeed have a serious problem. And I think ultimately—the students themselves are pretty astute at deciding what they want to study—so the rewards that society provides are ultimately going to be the determinant.

But I believe there are a number of practical things. One of them is it seems to me there would be some merit—well, the first thing we ought to do right away is to go back and rectify a serious error in the last tax reform, which was to deny tax deductibility for fellowships. That strikes me as the most negative kind of message the Government could possibly have sent to young students contemplating a tough period of graduate study, for a fellowship they have to apply for and be given as essentially a gift.

Secondly, I think there is merit in doing something specifically to encourage opportunities for American students in our graduate schools. I understand the universities will always want to bring in the smartest students—and that is what I will do at Harvard, too—whatever country they come from. But I don't see any reason why, if we could expand our fellowship programs in the critical skill fields, why we couldn't make a shift between using research assistantships off of research grants to fellowships. And those competitive fellowships have the virtue that they go to the individual, and he picks the school, but they go to Americans.

I think the time has come when we ought to look to sending a message to our people to say, "There is money for you if you want to pursue this as an American citizen."

I have already indicated I think there are some very special problems in certain fields like the areas of manufacturing engi-

neering, and there, I would only point out that we have to remember the National Science Foundation approaches education problems at the postgraduate level largely through the funding of research. It is an indirect means. And in the case of the downstream areas of engineering, where the engineering budget of NSF is quite modest, NSF has very little leverage to improve that higher education component. That is why I would like to see this new Technology Administration in Commerce step up to a human resource obligation in collaboration with NSF and talk to industry and talk to engineering schools specifically about what they might do.

The CHAIRMAN. What about at the undergraduate level? We hear comments about the dropouts, effectively, in terms of science, engineering, math, technology at a pretty early level, eighth, ninth, tenth grades, not enough teachers, and teachers not adequately trained. I guess now, for every one that is going into the math teaching area, twelve are leaving. We have seen flow lines in those areas. Obviously, the compensation in the private sector, again, is a force in terms of drawing these people out, but do you have ideas about, in the earlier grades, how we can make it more appealing, more attractive? Are there things that can be done?

Dr. BRANSCOMB. Indeed, I do. And I think you are in fact familiar with the program of recommendations from the Carnegie Corporation's Task Force on Teaching as a Profession. And in fact, I want to compliment you and thank you for your support of the appropriateness of the Federal Government participating with private gifts in the funding of the National Board for Professional Teaching Standards, because I think that is a major thing the Congress can do—must do—this year so that by 1993, the teachers can start certifying themselves with their own elevated standards of professional achievement. That is one step.

The second step is I think it is very important that the States move, as they are moving, but rather slowly, toward the abolition of the baccalaureate in education degree as the normal pattern for becoming a teacher and instead saying to young people who might want to be teachers, you don't have to decide when you are a freshman in college whether you are going to be a teacher or a scientist; go for the baccalaureate in science, and when you are done, you can choose—and by the way, we'll have this nifty masters in teaching program that you can do while you are employed in a school, in a real school, that gets you the appropriate State certification and gives you the professional training, and now you will have a full baccalaureate behind you, which is, after all, what your pupils should be aspiring for, too.

I think that would allow us to bring people into teaching who had not really thought about wanting to be a teacher until they were seniors. It would allow people who already have the baccalaureate, working in industry, to go into teaching with that masters degree. That is an important step for the colleges, and it would help rejuvenate the undergraduate majors in science.

The other thing, getting specifically to the NSF—I think the problem in the NSF is that NSF has been given by the Congress three big jobs. It has a budget of \$1.5 billion. I think it needs \$1.5 billion for each of the three jobs. One of them is science, one of them is engineering, and one of them is education. So they are tor-

tured with how do they jack up one and jack up the other a little bit; if they have to have a minority activity in engineering and in education, how can they get leverage from that?

And it seems to me that if we could get the right leadership in the Administration and help from the appropriate groups in Congress, who would have to work together, it must be possible to find ways that NSF, which has a fair amount of credibility in science and math education, can leverage their \$100 million with some of the \$20 billion in the education agency.

In other words, if NSF can do innovative things with school systems that are dedicated to reforming the structure, if NSF can get involved in the real nitty-gritty, everyday politics and practicality of public education, which they have been reluctant to do, but if they will commit themselves to that, becoming experts in it and trying to produce change, the Department of Education could help implement the change because it has got the resources.

NSF alone cannot pay for the broad dissemination of something that it proves works on a small scale. So I see a partnership there as one that has to be worked out somehow.

By the way, the Defense Department also has a major role in education and is an important actor in that.

The CHAIRMAN. Finally, as to the academic research facilities. Last year, we added small amounts of money, and worked out with the various large and small universities a way of proceeding on that. We are going to be hard-pressed, obviously, in funding these programs, and we are facing some concern, primarily with the investigations over in the House, about research credibility in Congressman Dingell's subcommittee.

How serious is the deterioration of research facilities at universities? I will give each one of you a crack at that.

Dr. BRANSCOMB. Well, my answer would be rather like Frank Press' answer. I think the facilities problem is serious in those fields of research where you really have to have a different kind of facility in order to do competitive work. But in terms of the paint peeling off the ceiling problem, which is substantial, I think we are forced by our budget situation to rely on other local sources for that.

I think the instrumentation and the equipment is the key issue, and it really is important.

Dr. HORNIG. I would agree. It is a serious matter, and you cannot do good science with 20-year-old equipment any better than you can manufacture well with ancient equipment.

The CHAIRMAN. We want to thank you very much for your appearance. As I mentioned earlier, we are going to try and take a look at the range of different programs before our committee and see how we can shape and leverage them to try and achieve some of the extremely worthwhile and useful suggestions that have been made here this morning.

As always, this panel, as well as the previous one, has been enormously helpful to us, and we want to thank you very much. As we move toward making this a "kinder and gentler" Nation, we are going to try and make it more scientific as well.

We want to thank you very, very much for your appearance.
The committee stands adjourned.

[Whereupon, at 11:20 a.m., the committee was adjourned.]

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